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EFFECTS OF THE FLOODING OF THE NETHERLANDS

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Description

An analysis of the effects of the flooding with salt or fresh water, the loss in agricultural and industrial production, the interruption to transportation, communication, and public utilities, population affected by flooding, and German territory from which areas for possible compensation might be chosen.

9 February 1945

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SUMMARY

Flooding land in . western Netherlands as a defense measure against allied invasion is a relatively simple matter because of the lay of the land. Behind the coastal dune belt, supported here and there by artificial dikes, is a broad polder and alluvial belt, most of which lies between sea level and six feet below sea level. The surface of the land in most of this belt is well below the level of the channels of the rivers and the main navigable and drainage channels.

As of 11 October 1944, 363,000 acres or 4.5 percent of the land area of the Netherlands had been flooded. In the southern part of the polder and alluvial belt the islands in the Scheldo-Rhine estuaries and a broad strip on the north shore of the Hollandsch Diep from the dunes in the west to beyond Dordrecht in the east are inundated. An almost continuous strip of flooded land extends from Ijsselmeer, well to the north of Amsterdam, west and south near the margin of the polders to the dune belt north of the Rhine. From Amsterdam an almost continuous inundated strip extends southward to a point near Gorinchem on the Rhine. In addition, Rotterdam and Amsterdam are nearly surrounded by strips or patches of flooded land.

The time and cost required to reclaim flooded land depend upon whether the flooding is with salt or fresh water, the depth and duration of inundation, the character of the soil, damage to dikes, retaining walls, pumps and other drainage facilities, and upon other conditions. About 61 percent of the inundated land is covered with salt water. In some places in the southern part of the region, where sea dikes and retaining walls were breached, the water may be as much as eight to ten feet deep. In other places with controlled flooding the water is only two to three feet deep. Most of the flooded land has heavy clay soils. While fresh-water inundation has little or no permanent detrimental effect on the

soil, salt water causes a change in the chemical and physical character of clay soils. Land flooded with fresh water may be planted to crops as soon as the soil dries out after it is drained. After salt water is drained from clay soils, it may take from three to five years to rehabilitate such soils for the growth of crops. It is estimated that the cost of pumping the water from the areas flooded, as of 11 October 1944, will be between Fl. 450,000 and Fl. 650,000. To this cost must be added $12,000,000 or more for the purchase of pumping and power plant equipment, drag lines, bulldozers, tractors and the pile-driving equipment. Where dikes and embankments are breached, additional expenditures will be necessary in their reconstruction before pumping can begin.

The loss in agricultural production as a result of flooding has been great, though not catastrophic. As of 11 October 1944, about 4.5 percent of the land area and 6 percent of the agricultural land of the Netherlands had been flooded. Some of the best agricultural land in the Netherlands has been inundated, with the result that the proportion of the total crop production loss is somewhat greater than the proportion of the total land area flooded. It is estimated that the land inundated formerly produced 22.7 percent of the sugar beets of the Netherlands, 11.3 percent of the potatoes, 9.1 percent of the wheat, 4.6 percent of the barley, and 2.7 percent of the oats. Lands in other parts of the Netherlands may not be able to replace these losses. Since cattle can be moved from inundated areas, the actual loss of cattle due to flooding is unknown. However, it is estimated that 8.7 percent of the acreage of green fodder crops and 5 percent of the grasslands of the Netherlands have been flooded.

The effect of the war and occupation upon Dutch manufacturing has been great, but comparatively little damage can be attributed directly, or even indirectly, to the inundation of portions of the Netherlands by the Germans. Flooding has been carried out

mainly upon agricultural lands. There are many industrial plants in western Netherlands, but these are almost invariably in urban areas, such as Rotterdam, Amsterdam, Haarlem, Dordrecht, Utrecht, and others, which have not been flooded. However, in the islands of Zeeland inundation covers urban areas of fairly good size. Also, throughout the flooded areas there are many small food processing plants, ceramics factories and others, which are believed to have been inundated. Damage to these plants would not greatly affect the total Dutch industrial facilities or output.

Although the western part of the Netherlands has the densest railroad, waterway, and highway networks and the major ports of the country, flooding in this region does not appear, according to all available information, to have affected seriously the transportation system of the country. Interruption to traffic movement has been greatest in the islands of Zeeland where dikes have been breached and where the floodwaters have reached greatest depths. While the flooded strips in other provinces cut across the main transportation routes, there is no evidence that traffic has been stopped by floodwater. Approximately 84 miles of railway lines cross the controlled flooded strips. The main waterways, railroad lines, roads and port facilities are generally constructed at a level well above that of adjacent lands. Consequently, controlled flooding of shallow depths would not cover them and interfere with their use. However, secondary transportation facilities in flooded areas may be destroyed or seriously damaged.

Inundation probably has not caused serious interruption of communications in the Netherlands. With an extensive communications network tandem routing or alternate services can be put into use during an emergency period. Since flooding has been confined largely to rural areas, only line connections and small centrals probably would be affected. Also, since cables are routed underground along highway dikes, controlled flooding of shallow

depth would not affect most of them. Communications have been most affected in the province of Zeeland. In the islands of Schouwen and Tholen, almost completely inundated, floodwaters will have affected the smaller centrals and station equipment as well as endangered the cable lines. Also in the island of Walcheren heavy central equipment and cable lines in Middelburg and Flushing have probably been flooded. Middelburg is the junction of the cable to Domburg, one of the two submarine cable landings in the Netherlands. Haarlem is the only other important city in which part of the central equipment may have been flooded. Major damage to central equipment, such as that of Middelburg and Haarlem, will eliminate service within the city and in the surrounding country and may knock out a potential trunk exchange for other inundated areas.

Electricity, which plays a vital role in the economy of the Netherlands, is generated chiefly in medium-sized and large power plants, interconnected only fairly well. Supply areas are well-defined and quite small. The 118,200 kw Velsen station, the 34,000 kw steam plant at Haarlem and the 12,000 kw steam station at Flushing are in flooded areas. These power plants and others may have been surrounded with dikes before flooding took place. If not, it is almost certain that water only two or three feet deep would fail to reach any vital parts of the stations. At Flushing, however, water may have reached a level high enough to prevent the plant from operating. Transmission and distribution cables throughout the country are mostly underground. At least thirteen important high-tension cables are in inundated areas, but their construction is such that little damage by flooding alone is expected. The damage by flooding to both electric plants and line equipment is expected to be slight and temporary in character.

It is estimated that the 363,000 acres of flooded land have a population of approximately 412,000. Large displacements of population in the provinces of western Holland have taken place.

Because of inadequate statistics, there is no way of determining how many of the displaced persons in the western provinces were driven from their homes in anticipation of flooding as opposed to those evacuated because of bomb damage, strategic exigencies, or a combination of all three factors. The population has been most affected by flooding in the province of Zeeland, where extensive areas as well as urban centers, such as Middelburg and Flushing, have been inundated. There probably are serious problems of displaced persons in Zuid-Holland, south of Rotterdam, and along the banks of the Rhine because of large population concentrations in these areas. Since the inundated areas in other provinces are strips of land usually not more than seven miles wide and mainly agricultural in character, population displacement may not be a serious problem. Many persons in flooded areas presumably have not abandoned their homes. A considerable number will want to remain and aid in reclaiming lands which have been flooded.

Since much of the land that has been flooded in the Netherlands is primarily agricultural, the most suitable compensation of German territory would be land similar in character and adjacent to the Dutch border. The types of land, such as polders, unreclaimed polder land, dry sandy heath (Sandgeest), the moor (Moorgeest), peat bogs and alluvial plains, and the economic activities on both sides of the Netherlands-German border are similar. Likewise, language, religious affinities, folkways, and cultural traits on either side of the border have many things in common. Several main railway lines and roads cross the Netherlands border into Germany. While the economic activities of German and Dutch areas adjacent to the international boundary are similar, they have been largely independent of each other. Any annexation, whether temporary or permanent, would cut through established connections within Germany. The lands that may be considered for compensation are

(1) the polder belt of East Friesland and Jeverland, (2) portions of the heath, the moor, and the Ems and other alluvial plains in Oldenburg, western Hannover, and northwestern Westphalia, and (3) the alluvial lands of Northern Rhineland.

Aside from the questions raised by cession of any territory, the transfer of western German border areas, either temporarily or permanently, would give rise to special problems. The delimitation and maintenance of a satisfactory political boundary is of primary importance. The terrain of these regions is so uniform that there are few natural breaks except those which are determined by the presence of bog and heath. With the large extent of heath and moor in this section of Germany, it probably would not be difficult to select a boundary which would pass through sparsely populated districts and which would not be crossed by many main roads or railways. The exact delimitation of such a boundary would have to be based on field studies. Cession of East Friesland and portions of western Hannover would necessitate some international regulation of the Ems-Jade and Dortmund-Ems Canals and the port of Emden.

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I. THE TIME AND COST REQUIRED TO RECLAIM LAND FLOODED WITH SALT OR FRESH WATER

The Germans planned to defend the Netherlands by flooding low areas south and west of the Ijsselmeer. The terrain here favors this method of defense. Along the immediate coast of the North Sea there is a dune belt, about two and a half miles wide, with dunes which rise as high as 200 feet above sea level. The dune belt, supported here and there by artificial dikes, extends from the mouth of the Ijsselmeer to the Rhine, and is continued on the exposed western side of the islands of the Rhine-Schelde delta region. East of this dune belt are the polders -- the low lands reclaimed from the sea. The polder belt is about forty miles wide. While most of it lies between sea level and six feet below sea level, parts of the belt are as much as fifteen feet below the sea. The polder belt also lies below the channels of the rivers and navigable canals which stand distinctly above the general level of the country. The banks of the Rhine (Lek) and Meuse Rivers and their distributaries are faced with masonry and bordered by two sets of dikes for normal and high-water stages. Flooding of some of the polders by salt water, others by fresh water and some by both is a simple matter, requiring only the opening of sluice gates or the destruction of the artificial dikes. Large parts of the plains east of the polder belt can also be flooded with fresh water although this part of the Netherlands is beyond the danger of salt-water inundation.

A. Extent of Inundation

Since 1 February 1944, certain of the polder lands have been inundated for purposes of defense. The Dutch

fear that a "flooded earth" rather than a "controlled inundation" policy may be followed as the Germans retreat to the Reich. It is considered improbable however, that the Germans will find it either convenient or expedient to flood to the fullest extent possible. Maximum flooding of the area below sea level would cover 46 percent of the country.

This report is based on the land known to be inundated by 11 October 1944 as reported by Dutch underground sources and corroborated by aerial photographs. (See Map No. 5889 and Table 1). Since that date, more land was inundated for defense purposes in anticipation of the recent fighting along the Rhine-Meuse-Schelde estuary. As is shown on Map No. 5889 and in Table 1, the flooding affects chiefly the provinces of Zuid-Holland, Zeeland, Noord-Holland, Utrecht, and Noord-Brabant in the polder belt south and west of the Ijsselmeer, and the polders in Overijssel to the east of the Ijsselmeer. As of 11 October 1944 the flooded area covered 363,000 acres or only 4.5 percent of the total land area of the Netherlands. Of the total, 140,000 acres (39 percent) have been flooded with fresh water, whereas 223,000 acres (61 percent) have been inundated with salt water. The Germans had hoped to prevent the Allies from establishing a foothold in the south by flooding the delta islands and a broad belt on the north shore of the Hollandsch Diep from the dune belt in the west to beyond Dordrecht in the east. Farther north they have attempted in the same manner to protect key cities and much of the polder belt. Both Rotterdam and Amsterdam are largely surrounded by strips or patches of flooded land. An almost continuous strip of flooded land extends from

the Ijsselmeer, well to the north of Amsterdam, west and south near the western margin of the polders to the dune belt north of the Rhine. A second almost continuous strip of flooded land extends south from Amsterdam across the polders to a point near Gorinchem on the Rhine.

Table 1. Areal Extend of Flooding in the Netherlands by Provinces
(Figures are in acres)

Province	1937 Area	Area Flooded (estimate)	Percent Flooded
Noord-Brabant	1,215,213	9,000	0.7
Noord-Holland	740,286	43,000	5.8
Overijssel	825,153	10,000	1.2
Utrecht	342,153	26,000	7.6
Zeeland	440,611	125,000	28.0
Zuid-Holland	743,510	150,000	21.0
Totals	4,306,926	363,000	8.4

Total land area of the Netherlands: 8,143,279

Total flooded area: 363,000

Percent of total land area flooded: 4.5

1. Fresh-water Inundation. Since the effects of salt-water and fresh-water inundation on land and equipment differ greatly, it is important, for purposes of estimating both damage and costs of reclamation, to ascertain where each type of flooding has occurred.[1] In

1. Under the Dutch defense plan of 1940 large areas were flooded with fresh water. (See Map No. 5889). Two main defense lines were planned and inundated. One of these was the Grebbe line, the first eastern defense line. It stretched from a point north of Baarn on the Ijsselmeer, southeast to Wageningen, and on to the Meuse River. The other was the Fortress of Holland, a line from the Ijsselmeer south through Utrecht and east of Gorinchem almost to the Meuse River. The third principal area of inundation by the Dutch in 1940 was a stretch north of Amsterdam, including part of the Beemster Polder. Since this land is now back in production, the area inundated has not been taken into account in this study.

the north, the Germans have flooded with fresh water, which is much less damaging to the soil. The two north-south belts of flooded territory in Noord-Holland and Zuid-Holland have been inundated by closing the sluice gates in the dike at the mouth of the Ijsselmeer and allowing it to fill up with fresh water. This has raised the ground water level and provided water to flood the polders. At the same time all pumping has been stopped, allowing seepage and rain water to collect. Extra water has also been taken from the Rhine River.

2. Salt-water Inundation. In the southwest, in southern Zuid-Holland and in the islands of Zeeland, most of the flooding has been accomplished with salt water. It is probable that this was done wherever it was possible since in most cases, enough fresh water for use in flooding was probably not available in the region. Instead, the sluice gates which protect the land from the open sea were opened at high tide and closed again at low tide, thus inundating areas adjacent to the sea.

B. Time Required for Reclamation

1. Drainage.

a. Pumping and Power Facilities. The initial step in reclamation of inundated land is drainage. This can be accomplished in a relatively short time if the facilities for drainage have not been impaired either by the flooding itself, by systematic German demolition, or by Allied strategic bombing. It is probable that many of the pumps will be in working condition immediately or soon after the German occupation ceases. If this is not the case, measures which are being taken at the present time should prove effective. It is reported that the Netherlands Purchasing Commission has ordered

200 pumps from the Worthington Pump and Machinery Corporation. These machines working at capacity would dispose of 3,500,000 gallons of water a minute. Diesel engines (also on order) will provide the power required to operate these pumps. In addition, 60,000 kw of portable electricity generating sets have been requested.

b. Time Requirement. If such facilities are available, the drainage process should not take long. The recent draining of the Ijsselmeer to form the Wieringermeer Polder may be cited as an example. Five pumps which disposed of 380,000 gallons of water per minute were used in the operation. Within six months 132,000,000,000 gallons of water were removed by these pumps and an area of 50,000 acres cleared of water which stood 16 feet deep. It is estimated that 115,500,000,000 gallons of water will have to be removed from areas flooded as of 11 October 1944. On the basis of the experience cited above, a pumping capacity of 2,660,000 gallons per minute (almost the same capacity per acre) would drain in approximately a month the present inundated areas, where the depth of water averages only two feet.

2. Cultivation.

a. After Fresh-water Inundation. Fresh-water flooding, when carried out in a controlled manner, has little or no permanent detrimental effect on the soil. This has been demonstrated in the Netherlands in as recent a case as the flooding done by the Dutch in 1940 in an effort to protect their territory from the German advance. After the Dutch surrendered and the occupation began, the land was drained within several weeks and a normal agricultural production realized by 1941.

b. After Salt-water Inundation.

i. Effect of Salt Water on soil. The situation is quite different when the land has been inundated with salt water. Salt water causes a change in the chemical and physical character of the soil. The composition of the clay in the soil is changed. The calcium normally held by the clay particles is replaced by the common salt constituent, sodium. The reaction in the clay particles is called deflocculation or de-granulation, and it renders the soil almost impervious to water. When the land has a low percentage of clay and a high percentage of sand, the effect is not serious, since the drainage is not materially affected; and as long as the water table is well below the surface, the salt washes out readily. The soil with a high percentage of clay is much affected by the chemical reaction. It is necessary to have an interchange of the sodium for the calcium before any recovery can take place. When the clay soil has a good supply of lime compounds, recovery begins as soon as drainage starts.

c. General Principles of Recovery. The process of recovery may be accelerated by (1) applications of lime or gypsum to the drained surface of the soil, (2) lowering the water level in the dikes, and (3) using supplementary drainage ditches. The final result should be a soil with a salt content of not more than 0.01 percent. When this has been accomplished, cultivation can be resumed. Until then, the soil should not be deeply cultivated or ploughed but a light harrowing to break the crust is beneficial. The first crops to be grown when the soil still has a high percentage of salt should be those of the mustard family -- rape, kale, and mustard. Following these, mangels, sugar beets, oats, and barley may be grown

successfully. If the period of flooding has been long, or the soil is heavy, the period of recovery is apt to be long. It may, however, be accelerated by implementing the drainage process and by correct cultivation.

d. Special Soil Conditions in the Salt-water Inundated Areas. In the salt-water inundated area of the south-western part of the country, in Zeeland and Zuid-Holland six soil types are affected. (See Map/ Soil Types Within the Salt Inundated Area.

i. Coastal Sands. The primarily loose coastal sands composed of material resulting from wave and wind action in western Zuid-Holland and the islands of Zeeland, are generally high enough to enjoy natural drainage but their quality is poor. Little is grown on them since they have a very low water-holding capacity and lack plant nutrients. There would be little difficulty in draining these soils in places where they are low enough to be submerged.

ii. Intricately Mixed Peats, Mucks, Loams, Sands and Gravels. River and marine deposition and concentrations of organic deposits have created a small, rich area just within the protective dunes along the coast of Noord-Holland and Zuid-Holland which has been devoted to horticulture. The complexity of the soils of this area makes it difficult to assess the effect of salt-water inundation. It would probably be easier to reclaim these soils, however, than the denser clays to the south.

iii. Fen Peat. Fen peat is relatively undecomposed organic material, produced by decaying vegetable matter within an enclosed body of water. Because it has been uneconomic to drain thoroughly and then reclaim this land, cultivation has not been possible. Most of

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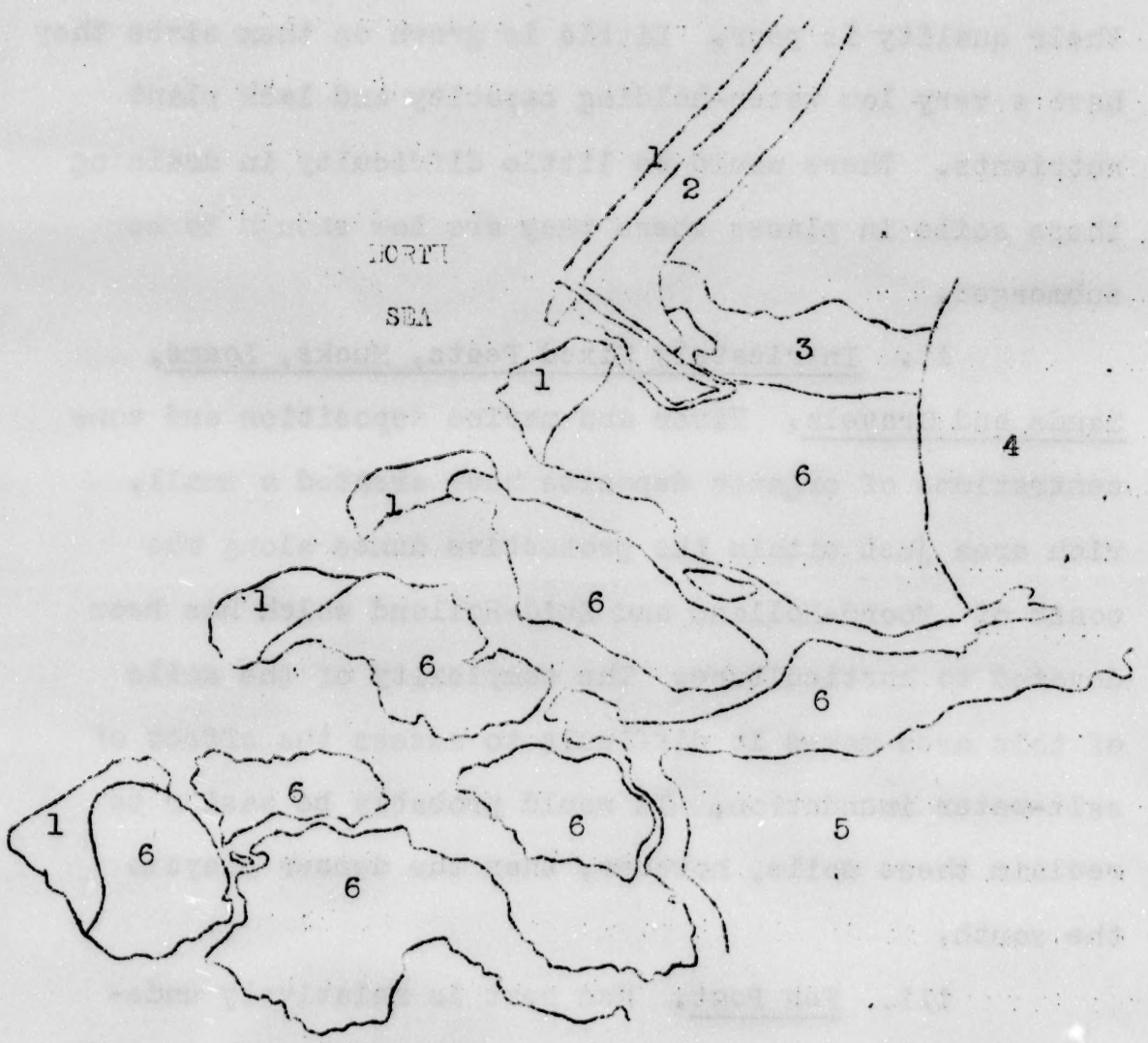
SOIL TYPES WITHIN THE SALT-INUNDATED AREA

1. Coastal sands
2. Intricately mixed peats, mucks, loams, sands and gravels
3. Fen peat
4. Undifferentiated alluvial clays
5. Mixed loams, sands and gravels
6. Clayey salt marsh



Note: Soil areas are approximate. Information was obtained from the Soil Conservation Service, Department of Agriculture.

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such areas are in pasture. The water table in such soils should be reduced by the drainage and pumping system to at least 18 inches below the surface. Within several months, after fertilization with phosphate and potash, the land may be suitable for the growth of vegetables and other specialized crops in the small areas formerly devoted to agriculture.

iv. Undifferentiated Alluvial Clays. Variable clays of heavy texture derived mostly from river deposition cover some of the easternmost sections of the flooded areas. To reclaim such land a permanent water table at least two feet below the surface needs to be achieved as soon as possible and followed with fresh-water flooding. The soil should then be treated with limestone, phosphate, and potash fertilizer. The texture will determine the length of time required for satisfactory crop production. The heavier clays will take at least 3 years before the salt concentration is lowered to crop tolerance. For crop tolerance a reduction of sodium chloride to three grams or less per litre of soil is necessary.

v. Mixed Loams, Sands, and Gravels. This type of land has been inundated on the mainland of Zeeland to a slight degree. The material, derived from wave action and mixed with river deposits during high flood stages, has a generally coarse texture with a porous subsoil. It can be drained readily because of the nature of the subsoil, but will require a heavy concentration of fertilizer to increase plant nutrient supply. If drainage can be accomplished in fall or winter, the land will be available for cropping the following season.

vi. Clayey Salt Marsh. Most of the soil which has been inundated with salt water is of clayey salt marsh

type, since most of Zeeland and a large part of Zuid-Holland have such soil. The soil of a very heavy texture derived from muds, mostly of marine origin, is difficult to drain. Because of its extent, areas of this type of soil will be the most vital to consider in the problem of reclamation, for in them both agricultural losses and population displacement will be large. In the process of reclamation the water table will have to be lowered 30 inches or more by rehabilitation of main and lateral ditches, the use of any previous tiling systems, and by draining. Rain water should be forced to percolate through the soil rather than to drain off immediately. A further reduction of the salt concentration may be accomplished by flooding with fresh water, if the latter is in sufficient supply. It will probably take at least three years before the sodium chloride content is reduced enough to permit cropping.

C. Cost of Reclamation

An estimate of the cost of reclamation should include not only the drainage by pumping, the dredging of former channels, and the fertilization and cultivation of the land, but also an estimate of the crop loss involved during the period of inundation, draining, and cultivation.

The pumping costs per 1000 cubic meters, including staff, electric current, oil, and maintenance of machines and buildings, will be approximately Fl. 1.00.[1] (This is an average figure since costs are approximately Fl. 1.30 when the pumps are run by electric power and only Fl. 0.70 when run by Diesel motors.) Since it has

1. A florin or guilder is equal to about forty cents.

been estimated that 115,500,000,000 gallons or 437,000,000 cubic meters must be drained, the total cost for the pumping itself would be between Fl. 450,000 and Fl. 650,000.[1] A further pumping cost will be the $12,000,000 which the Dutch are planning to spend in the United States for power plant, pumping facilities, draglines, bulldozers, tractors, and piledriving equipment.

It is more difficult to estimate the cost of the rehabilitation of the drainage channels and other surface damage. This will be determined by the cost of the equipment, the cost of labor, and the actual extent of damage, as well as the amount of time the operation will take. It is possible that much of this work might be done along with the drainage process, and that equipment used for reclamation of the Wieringermeer Polder might be utilized again. Whether it would be economical to move this heavy equipment or not is another question.

It is evident from the preceding soil type analysis that the crop losses will be different in the various soil type areas. Estimates of such losses are determined by (1) the value of the particular crop formerly grown in the area, (2) the length of time required to reduce the salt content to the correct concentration, and (3) the value of the crops which may be grown on the land in the meantime. An estimate of this figure is given in Section II.

1. This estimate is based on actual figures given for the draining of the Wieringermeer Polder in 1930. This drainage was done with the most up-to-date equipment, some of which was first developed especially for this task. To keep pumping costs to such a low level it will be necessary to have similar modern equipment.

II. THE LOSS IN AGRICULTURAL AND INDUSTRIAL PRODUCTION AS A RESULT OF FLOODING

A. Economic Patterns of Inundated Areas.

1. Land Use, Cultivation and Industrial Character of Inundated Areas. Some of the best agricultural land in the Netherlands has been lost by flooding, with the result that the proportion of the total crop production lost is somewhat greater than the proportion of the total land area flooded. (See map No. 5889 and table 1).

Of the six provinces partially flooded, the loss has been greatest in Zeeland. About 28 percent of Zeeland is now under water, mostly salt water. (See table 1). Zeeland has some of the most fertile soil in the Netherlands. Most of the land is used for grain and vegetable crops. Although Zeeland is one of the lowest provinces in the number of livestock per acre, each farmer keeps several cattle and horses for his own use. The few industrial enterprises are located in the towns of Flushing (Vlissingen) and Middelburg. The province lacks mineral deposits to encourage industrial growth, and its position at the mouth of the Rhine is largely discounted by the Zuid-Holland port of Rotterdam which derives the full commercial benefit accruing from Rhine traffic.

A larger area has been flooded in Zuid-Holland than in Zeeland, but the damage probably has been less, even though the best agricultural region in the south, an extension of the Zeeland belt of loam, has been almost entirely inundated. Elsewhere in the province only isolated spots and strips are flooded. The flooding of these small areas may not seriously hinder agriculture or industry. Zuid-Holland has a unique position among the Netherlands provinces in its position at the mouth of the Rhine shipping channel. The growth of many of the industrial establishments in Rotterdam and in its industrial suburbs has resulted in large part from this position. Most of the industry of Zuid-Holland is concentrated within about 25 km. of Rotterdam, including the important industrial

city of Dordrecht. Since most of the traffic on the Rhine is German, French and Swiss and since there is relatively little Dutch trade, the commercial influence of the river on Netherlands industry does not extend far beyond its banks. In contrast to Zeeland, Zuid-Holland has a large area of excellent grassland except for the southern strip of loam and a strip of sandy soil along the coast devoted to horticulture. The land is largely used for pasture. Zuid-Holland has one of the heaviest livestock populations, in the Netherlands. Among the animals are large numbers of swine, with the chief center in the southwest corner of the province near the Utrecht border. The horticultural belt along the coast, which extends into Noord-Holland, has not been affected by flooding, and since the sea wall in this region is largely natural, it is not likely to be affected. The flooding in Zuid-Holland seems to have been carried out systematically largely within two belts, both fairly well inland and parallel to the coast, to form invasion barriers. It is possible that flooding may take place later in the eastern part of the horticultural belt. This may also be true of the Rotterdam industrial region which is now practically encircled by inundated areas.

The damage through flooding in Noord-Holland has been relatively light. The province has two regions of especially fertile soil, one in the south and the other in the north. Neither of these has been seriously affected. Much of the province consists of grassland, but in the west there is an important horticultural belt, divided into many small farms. Noord-Holland is divided almost in half by a flooded belt which extends from Ijsselmeer west nearly to the dune belt and then south. In addition, several flooded spots and strips almost completely encircle Amsterdam, evidently designed to afford maximum protection to the city. Since the province is bounded on three sides by water, the amount of protective inundation required is not large. The main Netherlands

industrial belt ends just north of Amsterdam. Farther north the towns are primarily agricultural. Between Amsterdam on the east and Ijmuiden and Haarlem on the west is an important industrial area. This industrial area and the Noordzee Kanaal (North Sea Canal), which connects Amsterdam and Ijmuiden, is crossed by a broad flooded strip near the western margin of the polder belt. However, it appears that the major industries in this area have not been seriously affected, but it is not known how seriously the communications within the industrial zone have been damaged. Amsterdam itself is not in danger, except from the south, and this threat does not appear to be grave.

The other three affected provinces, Noord-Brabant, Utrecht, and Overijssel, contain only small, scattered flooded spots. It is doubtful that their agricultural or industrial economy has been changed greatly by inundation, except in the immediate vicinity of the few flooded spots. There is one flooded area in Noord-Brabant which is an important livestock raising district, and which may have necessitated a removal of stock to neighboring areas. This may be true of all three provinces, since most of the flooding has occurred within areas of grassland and pasturage.

B. Agricultural Losses.

In estimating agricultural losses both in acreage and output the following assumptions and working hypotheses have been employed as a basis for the analysis:

1. All loss has been calculated on the estimated flooded area as of 11 October 1944.

2. Other losses occurring from occupation and military operations have not been included in this analysis.

3. The loss has been based generally on statistics of the 1928-1937 ten-year average rather than on an estimated 1944 production; the fact that the type of crop grown may have changed appreciably in some of the areas now flooded, owing to the demands of a wartime

economy, has not been taken into account.

4. Land reclamation has been going on continuously in the Netherlands, resulting in a year by year increase in arable area. This steady increase in agricultural acreage, other than that expressed in the ten-year average for the period 1928-1937, has not been taken into account.

5. Although output per acre varies appreciably within each agricultural district, it has been necessary to assume an average yield per acre for each agricultural district.

6. For the purposes of analysis the fact that losses due to flooding in one part of the country may be partially offset by increased agricultural output in non-floodable sections has not been taken into consideration in the estimate. Such, however, may well be the case.

1. Quantitative Loss in Utilizable Area.

a. Loss by Acreage. Table 2 gives absolute loss in utilizable area of principal crops due to salt-water and fresh-water flooding. The table is based on official Dutch Agricultural Statistics of 1939[1] which give the area under cultivation by principal crops in hectares for the ten-year average of 1928 to 1937 broken down by agricultural districts in each province. To arrive at the figures in Table 2 it was first necessary to estimate by map inspection and arithmetical approximation the extent to which each agricultural district had been flooded. The percentages of arable land lost were used to determine loss in hectares of principal crops grown in these agricultural districts, based on the 1928 to 1937 average. The total loss in hectares of each crop according to province was then obtained by adding the total acreage loss of all agricultural districts within each province. The total loss in hectares of each crop for the Netherlands was obtained

1. Directie van den Landbouw, Verslagen en Mededeelingen, 1939, ('s-Gravenhage, 1939). No. 2.

by totalling the provincial losses.

It was then desirable to determine the proportion of loss due to salt-water and to fresh-water inundation. The reason for this distinction between the different kinds of inundation is that whereas a fresh-water flooded area can be reclaimed immediately upon drainage, a salt-water flooded area is likely to take up to five years to be reclaimed. Loss of agricultural land by salt-water flooding is therefore a long term loss in the food economy of the Netherlands.

Whereas most districts are either wholly salt-water flooded or wholly fresh-water flooded, there are three agricultural districts, two in Zeeland and one in Zuid-Holland, which have some districts flooded with salt water and others with fresh water. An estimate was made of the portions of these three districts flooded by salt water; these percentages were applied to break down the total inundation losses into loss by salt-water and fresh-water flooding. Total loss by salt-water flooding was then derived by adding the totals of crop losses by salt-water flooding in each agricultural district. The loss for each crop in hectares by salt-water flooding was subtracted from the total loss by salt-water and fresh-water flooding of each crop to get the total loss in hectares by fresh-water flooding. The total losses of area in hectares were then converted to acres.

Table 3 gives the relative loss in acres, i.e., the acreage loss of each principal crop in the Netherlands by flooding in percentage of total acreage under each crop in the Netherlands.

2. Quantitative Loss in Agricultural Output.

a. Various Products of the Soil. Quantitative loss in agricultural output for products of the soil was obtained by using the official Dutch statistics for average kilogram yield per hectare of individual commodities per province over the period 1933-1937 and multiplying it by the loss in hectares of individual commodities

per province. (The figures for loss in hectares of individual crops per province were obtained in the process of computating Table 2). The resulting figures of lost output per province in principal crops were added to give the total loss in the Netherlands in each crop. To obtain the ratio of loss in crop yields to total Netherlands output, the total production of the Netherlands for the year 1938 was used. 1938 was chosen as the base year inasmuch as it was the latest year for which statistics are available. It should be kept in mind, however, that 1938 was an unusually productive year for almost all agricultural commodities.

b. Livestock and Stock-breeding. Unfortunately, statistics are not available by which a possible loss of livestock as a result of inundation of agricultural land may be computed. Even if such were the case, an accurate quantitative estimate could not be made, because the livestock may be moved from flooded to non-flooded grazing lands. Therefore, all that can be done with the data now available is to consider certain major effects of the policy of inundation upon the livestock situation.

The Netherlands is particularly important as a cattle-raising country, but with the exception of Zuid-Holland and part of Utrecht, the best cattle raising districts are not those which are affected by the inundations. The country as a whole, during the war. has suffered large losses in livestock and poultry, occasioned by shortages of feedstuffs (imported fodder is necessary to supplement Dutch-grown feed), heavy German requisitions, and increased slaughtering programs. It is estimated that inundations have caused an acreage loss of green fodder crops of 8.7 percent while 5 percent of Dutch grassland has been flooded.

In areas which have been flooded the practice is to remove herds of livestock to other grazing lands. This has been implemented by an order compelling owners of non-flooded grazing land to

place it at the disposal of displaced livestock. Hence it may be assumed that loss of livestock as a result of planned inundations has not been large, although in the case of Walcheren Island the situation is believed to be somewhat worse.

c. Dairy Production. The decline in livestock during the war years has had far more effect upon the output of dairy products than has inundation of grazing lands. The flooding of certain farms will, of course, further reduce the output of dairy products, but this effect does not appear to be great. The largest and most highly developed dairy plants are not located in this region but rather in the northeastern provinces, and have not been affected by inundation..

C. Industrial Losses

Although the effect of war and occupation upon Dutch industry has been great and has caused many strains and stresses, comparatively little damage can be ascribed directly, or even indirectly, to the inundation of certain parts of the Netherlands by the Germans This is to a considerable degree the result of flooding as a defense measure rather than a manifestation of scorched earth policy. Except in the case of the islands of Zeeland and of Zuid-Holland, inundation has been carried out mainly upon agricultural lands, and has not, as a rule, affected urban regions.

Much Dutch industry, including a large production of the nation's heavy industry, is located in the eastern and southeastern portions of the country and thus cannot be affected by the execution of inundation plans. There are many industrial plants in the western provinces also, but these are almost invariably in urban areas, such as Rotterdam and Amsterdam and nearby cities such as Haarlem, Ijmuiden, Dordrecht, and Utrecht, which have not been flooded.

The most important instances of inundation as far as industry is concerned are to be seen in the islands of Zeeland. Here, flooding (partly as a result of allied air action)includes or threatens

urban areas of fairly good size. It is known that some industrial plants have been removed from this area to locations in the eastern provinces, of which the most specific example available is the De Scheldo aircraft works of Flushing. Two other installations of some importance -- an accumulator factory and an oil refinery -- are also located in Flushing. While their present status is not clearly determined, these plants are the most important to be imminently affected or threatened by inundation. There are two shipyards of moderate importance in towns in Zeeland which have been inundated. Whether these shipyards have been directly affected is not known, but that is considered likely.

Throughout the various flooded areas of the Netherlands there are instances of small plants which are believed to have been inundated. Most of these are ceramics or food-processing factories, whose lack of importance makes it improbable that any effort has been made to protect them. Damage done to these plans would not be of noticeable effect upon total Dutch industrial facilities and production.

D. Evaluation of Dutch Claims.

There has been a series of official and semi-official claims as to the amount of damage done by flooding in the Netherlands. These claims have mainly emanated from the Dutch government-in-exile in London, and have been voiced in other countries by its bureaus and agencies. As might have been expected, these claims have been based on the maximum amount of damage which could reasonably be inflicted, and they take into account a great many factors not directly attributable to flooding. In this evaluation an attempt is made to reduce the claims to compatibility with inundation as of 11 October 1944.

On 6 October 1944, Eelco van Kleffens, Netherlands Foreign Minister, said, "Between 60 and 65 percent of the entire population has been affected by the floods let loose upon the country by the enemy, . . . while 46 percent of Holland's total area is threatened

by inundation . . .' On the same day, Premier Pieter Gerbrandy stated, ". . . close to 20 percent of our agricultural land has been ruined for many months to come, in many cases for years to come, and even greater devastation by floods and inundations impends." More definitive figures were released in an official statement which claimed, "The following figures are based on known German defense plans which have already been largely carried out, and whose execution is still being completed: Arable land flooded -- 675,000 acres, or 22 percent of the total arable land in the Netherlands; pasture flooded -- 327,500 acres, or 11 percent of the total pasture land in the Netherlands; total flooded -- 1,000,000 acres, or 17 percent of the total arable land and pasture.... In terms of the present (1944) prospective crop losses resulting from these inundations, the figures are: Wheat, 30 percent; barley, 40 percent; sugar beets, 50 percent; potatoes, 25 percent; oil seeds, 25 percent; oats, 10 percent. In the case of dairy produce and meat, losses are 10 percent for both categories. For the most densely populated provinces in the west and center, these percentages are higher."

A quick comparison of some of the figures quoted above with those tabulated in this report shows that the Dutch claims are two, and in some cases eight times higher both in area adjudged to be flooded and in calculated crop losses. The following table briefly illustrates the disparity in crop loss estimates.

TABLE 5

Crop	Percent Loss (Dutch)	Percent Loss (OSS)
Barley	40	4.6
Wheat	30	9.1
Oats	10	2.7
Sugar Beets	50	22.7
Potatoes	25	11.3

The Dutch in stating their claims gave two premises which somewhat reduce the apparent disparity as shown in the table above. First, their figures are based on prospective 1944 corps, and, second, they assume the loss of all floodable area. Opposed to the

OSS estimates which do not take into account future flooding and are based on average crop yields over ten pre-war years, the Dutch figures are naturally larger. It has been the purpose here to show only actual inundation and the long-term view of drainage and reclamation necessary to restore the land to cultivation. In the face of the imminent famine in the Netherlands, it is understandable that the Dutch should have accentuated the immediate prospects, and it must be admitted that these are worse than is indicated in the OSS figures.

In interpreting tables 2, 3, and 4, it must be remembered that the percentages of loss shown do not represent a static condition. It is possible that the Dutch have tried to equalize the production of the staple crops by replacing less critical crops in non-flooded areas. This possibility has not been accounted for in the tables because the whole pre-war agricultural system in the Netherlands, with each district subsisting mainly on local produce and with the limited activities of the cooperatives, has acted to make it difficult to distribute the yield over a wide area. With the present grave transportation situation this difficulty has been accentuated.

The most significant difference between the Dutch and OSS figures lies in the area flooded. The Dutch claim 1,000,000 acres and OSS estimates 363,000 acres. Part of this difference is due to the fact that, as stated above, the Dutch presume all floodable territory will eventually be flooded by the Germans, but another probable reason is that they assume regions containing a number of small flooded basins to be entirely lost to agriculture. While this last assumption may well be true, it is due as much to mine fields, trenches, and sundry other military reasons as to flooding, and hence only the basins are counted in the OSS estimates. The whole question of what they regard as flooding has not been made clear by the Dutch, and in the light of their large estimates, it

is reasonable to assume that they have taken in areas not actually flooded. The land occupied by mine fields, trenches and other military installations may be restored to cultivation soon as opposed to those flooded. The latter may take up to five years in some cases. Therefore estimates of the territory which has been semipermanently incapacitated ought not to include the former type of area.

There are also changes in the agriculture of the Netherlands due to German occupation. Among these has been the replanting of arable land with crops, such as rapeseed, which are urgently needed in the Reich. Such crops are intended almost entirely for export, and are not integrated with the normal agricultural economy of the country. Such land will have to be again replanted, which will delay at least another full season the final recovery of Netherlands agriculture. The considerable displacement of the livestock population will also impede recovery. Many years would ordinarily be required to restore the cattle, swine, and poultry which have been killed by military operations, wantonly slaughtered, or shipped to Germany. These factors are undoubtedly included in the Dutch claims but are not properly accountable to flooding.

The Dutch have not made any specific claims as regards industrial loss, but they have stated that a fairly large percentage of their industry is located within floodable areas. Nevertheless, industrial plants have been practically universally located on the highest ground available. A review of the plants located within the flooded region, as given in the preceding section, has shown that only one plant of any importance was at all affected by flooding. It is, however, true that plants might be affected by other military operations, and could also be closed down by secondary effects of flooding, such as the incapacitation of transport or communications lines, or the inundation of raw material resources. As the major industrial areas of the six flooded provinces have not

TABLE 2. DUTCH LOSSES IN AGRICULTURAL ACREAGE, DUE TO SALT-WATER AND FRESH-WATER INUNDATION, on the basis of land use for the period 1928-1937
(in acres)

	ACREAGE LOST BY SALT-WATER FLOODING (in acres)	ACREAGE LOST BY FRESH-WATER FLOODING (in acres)	TOTAL ACREAGE LOST BY INUNDATION (in acres)
Wheat - Winter	20707	8955	29662
Summer	452	437	889
Rye	529	1725	2254
Barley -Winter	373	385	759
Summer	3138	1789	4927
Oats	6281	3870	10151
TOTAL ALL GRAINS	30566	17176	48632
Horse and Broad Beans	154	922	1076
Field Peas	10346	4823	15169
Field Beans	3724	1035	4759
TOTAL DRY LEGUMES	15229	6771	21999
Rapeseed	285	148	430
Flax	2622	1569	4191
Field and Garden Seeds	462	398	860
Other Commercial Crops[a]	934	1322	2256
TOTAL COMMERCIAL CROPS	4290	3432	7722
Potatoes - Consumer	20811	5350	26160
Starch	-	-	-
Sugar Beets	15977	5098	21075
Feed Root Crops	5209	3356	8565
Other Root Crops[b]	4507	153	4660
TOTAL ROOT CROPS	45392	13818	59210
Green Fodder Crops	7492	3242	10734

a. Mustard, Caroway and Poppy Seed
b. Includes Chicary and Onions

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Table 2. (continued 2)

	ACREAGE LOST BY SALT-WATER FLOODING (in acres)	ACREAGE LOST BY FRESH-WATER FLOODING (in acres)	TOTAL ACREAGE LOST BY INUNDATION (in acres)
Fallow Land	20	44	64
Total Arable Land	104575	43796	148371
Total Grass Land	48839	104758	153597
Total Horticultural Land	5056	7870	12926
TOTAL LAND IN AGRICULTURAL USE	184549	156421	340970

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been flooded, the industrial structure and output have been little affected.

TABLE 2. DUTCH LOSSES IN AGRICULTURAL ACREAGE, DUE TO SALT-WATER AND FRESH-WATER INUNDATION, on the basis of land use for the period 1928-1937
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Table 3. TOTAL ACREAGE LOSS OF PRINCIPAL CROPS IN THE NETHERLANDS BY SALT AND FRESH WATER FLOODING
(in percentage of total acreage under each crop in the Netherlands)

	ACREAGE LOST BY SALT-WATER FLOODING (in %)	ACREAGE LOST BY FRESH-WATER FLOODING (in %)	TOTAL ACREAGE LOST BY INUNDATION (in %)
Wheat - Winter	6.8	3.	9.8
Summer	.8	.8	1.6
Rye	.1	.3	.4
Barley -Winter	1.1	1.2	2.3
Summer	5.5	3.1	8.6
Oats	1.9	1.1	3.0
TOTAL ALL GRAINS	2.4	1.3	3.7
Horse and Broad Beans	.5	3.4	3.9
Field Peas	10.3	4.8	15.1
Field Beans	18.9	5.2	24.1
TOTAL DRY LEGUMES	10.3	4.6	14.9
Rapeseed	5.7	3.	8.7
Flax	10.3	6.2	16.5
Field and Garden Seeds	2.9	2.5	5.4
Other Commercial Crops[a]	2.9	4.1	7.0
TOTAL COMMERCIAL CROPS	5.5	4.4	9.9
Potatoes - Consumer	7.3	1.8	9.1
Starch	-	-	-
Sugar Beets	15.	4.7	19.7
Feed Root Crops	3.6	2.3	5.9
Other Root Crops[b]	34.1	1.2	35.3
TOTAL ROOT CROPS	7.4	2.3	9.7
Green Fodder Crops	5.7	2.4	8.1

a. Mustard, Caroway, and Poppy Seeds
b. Includes Chicory and Onions

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Due to its large size, the following document has been filmed in segments. The order of the segments is as follows: left to right, top to bottom.

NETHERLANDS
AREAS OF INUNDATION

INUNDATED AREAS

Areas flooded as of 11 October 1944 [2]

Areas flooded between 11 October and 18 November 1944 [2]

AREAS SUBJECT TO INUNDATION

Areas flooded by the Dutch in 1940

Areas prepared for flooding by the Dutch in 1940

Other areas easily flooded [4]

Areas not easily flooded

◇ Principal flood control center

—·—·— International boundary

—··—··— Provincial boundary

1 Main roads and railroads are above water level in most flooded areas.

2 Information from aerial photographs.

3 The estimate of possible flooding in areas near main rivers is based on their summer levels.
Flooding in these areas will become progressively easier as the levels rise during the winter.

4 Disconnected areas of higher land are likely to remain above water, especially in Friesland.

0 5 10 15 20 25 30 35
STATUTE MILES

0 5 10 15 20 25 30 35
KILOMETERS

RELIABILITY OF DATA				
DATA	QUAN.	QUAL.	LOC.	Quantitative & Qualitative Data
INUNDATED AREAS	GR-C		NE	R - Reliable
AREAS SUBJECT TO INUNDATION	R-C	R-C	NE	GR - Generally Reliable
CONTROL POINTS	GR-I		A	U - Unreliable
RIVERS & CANALS	R-I		A	Coverage of Data
				C - Complete
				I - Incomplete
				Location of Data
				A - Accurate
				NE - Not Entirely Accurate
				OA - Only Approx. Accurate

QUANTITATIVE DATA The letters R, GR, and U are an estimate of the reliability of the map's quantitative data, the data which are measurable, including economic or population statistics, hypsometric data, the width of roads, gauges of railroads, etc.

QUALITATIVE DATA The letters R, GR, and U are an estimate of the reliability of the map's qualitative data which shows the types of road surfaces, character of beaches, types of terrain, etc.

4°30' 5° 5°30' 6°

53°30'

53°

52°30'

3°30' 4°

NOORDZEE

WADDENZEE

HOLLAND

FRIESLAND

DRENTE

OVERIJSSEL

GRONINGEN

IJSSELMEER

TEXEL

VLIELAND

TERSCHELLING

AMELAND

SCHIERMONNIKOOG

BOSCHPLAAT

SIMONSZAND

FRIESCHE WAD

LAUWERS ZEE

Den Helder

Harlingen

Franeker

Leeuwarden

Dokkum

Sneek

Steenwijk

Meppel

Enkhuizen

Hoorn

Alkmaar

Velsen

IJmuiden

Zaandam

MARKEN

URK

SCHOKLAND

Kampen

Zwolle

Possible extension northward not known

Amstel Meer

Noord Hollandsch Kanaal

Westfriesche Vl.

Alkmaarder Meer

Nieuwe Diep

Zuider Zee

Dokkumer Ee

Dokkumer Nieuwe Zijlen

Kollumerwaard

Lauwers Zee

Reitdiep

Hoendiep

Boorne Ee

Zuidlaardermeer

Reitdiepskanaal

Beerta Boven Diep

Beerta Wijde

Beerta Diep

Beerta Meer

Beerta Kanaal

Reiderwold

Reiderwoldsche Boezem

Reiderwoldsche Diep

Reiderwoldsche Meer

Reiderwoldsche Kanaal

Oude Diep

Nieuwe Diep

Oude Vaart

Nieuwe Vaart

Bolsward Trekvaart

Zuidlaardermeer

Boven Dingsvaart

Nieuwe Vaart

Jonkers Vaart

Drachster Compagnons Vaart

Oosterse Compagnons Vaart

Noorder Compagnons Vaart

Ee

Wijde Ee

Gaast

De Gaast

Sneeker Meer

Morra

Vlakke Broeken

De Fluessen

Sloter Meer

Tjeuke Meer

De Morra

Beulaker Wijde

Het Belter Wijde

Meppelerdiep

Hoogeveensche Vl.

Zwarte Meer Kanaal

Zwolsche Diep

Dedemsvaart

Overijsselsche Kanaal

Vecht

Smilder Vl.

Hoendiep

Drentsche Diep

Hoogeveensche Vaart

Hasselter Vaart

Kanaal Tjonger Weg

Haskona Vl.

Kolonelsdiep

RIVERS & CANALS	R I		A

Coverage of Data
C - Complete
I - Incomplete
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QUALITATIVE DATA The letters R, GR, and U are an estimate of the reliability of the map's qualitative data which shows the types of road surfaces, character of beaches, types of terrain, etc.

COVERAGE The letters C and I in combination with R, GR, or U are an estimate of the degree of completeness of quantitative and qualitative data.

LOCATIONAL DATA The letters A, NE, and OA are estimates of the plotted accuracy of data within the limits of scale and width of line.

R A, OSS

GLOSSARY

Beek	brook
Diep, diep	canal or channel
Hoofdvaart: Hoofdvt	main canal
Kanaal: Kan	canal
Meer	lake
Plas (sen)	lake(s)
Trekvaart: Trekvt	(ship) canal
Vaart, vaart: Vt	(navigable) canal
Vliet, vliet	brook or small canal
Wijde	lake
Zee	sea

NOORD-HOLLAND
ZUID-HOLLAND
ZEELAND
UTRECHT
GELDERLAND
NOORD-BRABANT
LIMBURG
IJSSELMEER
MARKEN
BELGIUM
GERMANY
Amsterdam
Haarlem
Velsen
IJmuiden
Zaandam
Katwijk aan Zee
Leiden
Scheveningen
's-Gravenhage (The Hague)
Delft
Hoek van Holland
Rotterdam
Maassluis
Schiedam
Vlaardingen
Briell
VOORNE
PUTTEN
IJsselmonde
GOEREE
BEIERLAND
Dordrecht
SCHOUWEN
OVERFLAKKEE
DUIVELAND
THOLEN
NOORD-BEVELAND
WALCHEREN
ZUID-BEVELAND
Middelburg
Vlissingen (Flushing)
Terneuzen
Roosendaal
Bergen op Zoom
Breda
Tilburg
Turnhout
Antwerpen (Antwerp)
Hilversum
Amersfoort
Utrecht
Zeist
Ede
Gorinchem
's-Hertogenbosch
Eindhoven
Helmond
Weert
Harderwijk
Kampen
Zwolle
Deventer
Apeldoorn
Zutfen
Nijmegen
Arnhem
Rheden
Cleve
Emmerich
Goch
Venlo
Roermond
Information incomplete below dashed line
52 30'
52'
51 30'
3 30'
4
4 30'
5'
5 30'
6

NO. 5889-R&A, OSS
6 JANUARY 1945

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LITHOGRAPHED IN THE REPRODUCTION BRANCH, OSS

Table 3. (Continued 2)

	ACREAGE LOST BY SALT WATER FLOODING (in %)	ACREAGE LOST BY FRESH WATER FLOODING (in %)	TOTAL ACREAGE LOST BY INUNDATION (in %)
Fallow Land	.4	.8	1.2
Total Arable Land	4.6	1.9	6.5
Total Grass Land	1.5	3.2	4.7
Total Horticultural Land	1.7	2.6	4.3
TOTAL LAND IN AGRICULTURAL USE	3.2	2.7	5.9

NOTE: In view of permanent land reclamation in the Netherlands the latest 5 year average (1933-1937) of total Dutch agricultural acreage has been used in computing these percentage ratios.

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TABLE 4. LOSS IN OUTPUT OF PRINCIPAL CROPS, BASED ON 1928-37 AVERAGE PRODUCTION
(in metric tons)

	ZEELAND			ZUID-HOLLAND			NOORD-HOLLAND		
	a.	b.	c.	a.	b.	c.	a.	b.	c.
Wheat (winter and summer)	3,161	6,689	21,143,929	3,317	4,665	15,473,805	3,250	558	1,813,500
Rye	2,114	450	951,300	2,382	55	131,010	2,146	30	64,380
Barley(winter and summer)	3,141	1,543	4,846,563	3,145	389	1,223,405	2,861	88	251,768
Oats	2,121	1,708	4,989,068	3,121	1,825	5,695,825	3,385	161	544,985
Horse and Broad Beans	2,501	588	1,470,588	2,491	145	361,195	2,464	59	145,376
Field Peas	2,558	3,037	7,768,646	2,951	2,653	7,829,003	2,576	217	558,992
Field Beans	2,217	1,760	3,901,920	2,354	109	256,586	1,731	13	22,503
Rapeseed	1,907	86	164,002	2,089	71	148,319	1,704	4	6,816
Flax	5,133	1,337	6,862,821	5,167	280	1,452,360	6,057	17	102,969
Potatoes - consumer	20,090	5,485	110,193,650	22,960	4,336	99,554,560	19,530	278	4,921,560
Sugar Beets	41,100	4,704	196,622.4	40,300	3,034	123,787.2	36,300	281	10,200.3

a. Average kg. yield per hectare based on 1928-1937 average.
b. Hectare loss by flooding based on 1928-1937 average.
c. Loss in output in kg.

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Table 4. (Continued 2)

	UTRECHT			NOORD-BRABANT			OVERIJSSEL			Total loss in Netherlands	1938 crop production in Netherlands	Ratio of loss to 1938 crop yields in %
	a.	b.	c.	a.	b.	c.	a.	b.	c.			
Wheat (winter and summer)	2,108	21	44,268	2,691	415	1,116,765	2,672	16	42,752	39,635.0	433,762.0	9.1
Rye	2,000	33	66,000	1,899	84	159,516	2,192	260	569,920	1,942.1	551,059.5	.4
Barley(winter and summer)	2,119	6	12,714	2,410	57	137,370	2,549	6	15,294	6,487.1	140,464.8	4.6
Oats	1,741	50	87,050	1,829	226	413,354	2,147	139	298,433	12,029.7	446,549.5	2.7
Horse and Broad Beans	1,827	18	32,886	2,023	27	54,621	2,277	3	6,831	2,071.5	25,160.8	8.2
Field Peas	1,832	11	20,152	2,441	219	534,579	2,029	2	4,058	16,715.4	103,645.0	16.1
Field Beans	1,601	3	4,803	2,012	37	74,444	1,891	4	7,564	4,267.8	7,776.8	54.9
Rapeseed	1,069	2	2,138	1,746	11	19,206	1,525	-	--	340.5	6,078.7	5.6
Flax	--	-	--	5,016	62	310,992	1,200	-	--	8,729.1	118,750.4	7.4
Potatoes - consumer	12,950	59	764,050	17,430	304	5,298,720	16,380	151	2,473,380	223,205.9	1,973,521.3	11.3
Sugar Beets	38,500	2	77.0	35,700	426	15,208.2	34,700	2	694	345,964.5	1,519,503.0	22.8

a. Average kg. yield per hectare based on 1928-1937 average.
b. Hectare loss by flooding based on 1928-1937 average.
c. Loss in output in kg.

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III. THE INTERRUPTION TO TRANSPORTATION, COMMUNICATION AND UTILITIES

A. Transportation

The flooding of the Netherlands does not appear, according to all available information, to have affected seriously the transportation system of the country. Important waterways, railroad lines and roads are generally constructed at a level well above that of the surrounding land, so that the water level of the flood will not cover and interfere with their use. The interruption of regular farm to market connections is of little importance, since agricultural production in the areas involved is probably at a minimum.

1. General. In the Netherlands vessels on inland waterways and motor trucks lead in the carriage of goods in domestic and foreign traffic. Since the waterway system was extensive and efficient, rail transportation was relatively late in developing. The Dutch railways serve primarily for passenger transportation, whereas the waterways carry bulk commodities for which they are eminently suitable. With the advent of the automobile, extensive road construction was carried out in the Netherlands. The development of good trunk and feeder roads has made it possible for motor transportation to compete successfully for the agricultural produce carried by the waterways and the passenger traffic of the railroads. Before the war, waterways handled 55 percent of the freight transported inside Dutch territory, motor trucks carried 32.5 percent and the railroads only 12.5 percent. Dutch transportation routes not only serve the economy of the country, but also provide important channels for traffic to and from the industrial regions of Germany and the rest of Central Europe.

2. Inland Waterways. The Dutch rivers with their affluents and distributaries, as well as large canals with numerous branches, form an excellent and vital system of communication, and the flooded areas are intersected by a considerable part of this dense network. At least a small stretch of most of the waterways is located in regions already inundated by the Germans, or in those that can be flooded without difficulty (Map No. 5889). Among these, the chief arteries are listed below:

a. East-West direction

i. Noordzee Kanaal

ii. Hollandsche Ijssel

iii. Lek River

iv. Waal River

v. Maas River

b. North-South direction

i. Noord Hollandsch Kanaal

ii. Zaan Kanaal

iii. Merwede Kanaal

iv. Schie and Vliet Rivers

v. Maas-Waal Kanaal

vi. Zuid Willems Vaart Kanaal

vii. Ijssel River

viii. Apeldoornsche and Grift Kanaals

ix. Overijsselsche Kanaal

c. The circular waterway known as Ringvaart. It is connected in the north with the Noordzee Kanaal by the Spaarne River, and in the south with the Vliet River and the Oude Rijn at Leiden by the Leiden-Ringvaart waterway.

The major canals are generally built close to sea-level and well above the level of the adjacent land. This is particularly true in the western part of the Netherlands.

Moreover, rivers are usually bounded by fairly high dikes, in many cases 15 feet and more above the summer water level. Embankments are built to withstand a 6- to 7-foot rise in water level. Some form of protection is provided against wave action. This may consist of wooden sheet-piling below water level, capped by concrete blocks, bricks or stones, or may consist of mattress-work fascines or a stone revetment. On locks the motive power for the operating mechanism is usually placed well above the highest water level. Breaching of the dikes inundates adjacent territory but draws little water from the waterway's deep channel in the center. Consequently the major waterways are only slightly affected by controlled inundation. Minor waterways, however, most of which are little more than drainage ditches and of little importance to the transportation of freight, suffer much more. As a common mode of propulsion on the minor canals is "poling" from the canal bank, traffic ceases until banks are rebuilt, unless towing craft can be provided.

In general, serious interruption of traffic does not result from flooding, as such. This, however, can be achieved by the destruction of bridges across waterways, so that the wreckage obstructs the channel, by scuttling floating equipment, and by damaging locks.

Facilities of the ocean and inland ports have, so far as is known, not been affected by flooding. Whatever protracted interruption may be achieved in the functioning of the major ports will result from actual demolition of port installations rather than from flooding, because in these cases docks and their approaches are built well above the level of the adjacent land.

3. Roads

a. Road Construction in the Netherlands. The soft subsoil of peat and clay -- from 10 to 30 feet deep -- in

the low-lying western provinces of the Netherlands presents serious problems for the construction of stable road foundations. Four principal methods are used: (1) where the layers of peat and clay are not too deep they are excavated entirely, in order that the foundations may be laid on a stratum of compact sand below; (2) when the soft subsoil is too deep for economical excavation and replacement with sand, it is only partially removed, and the remainder is left to be compressed by the weight of the sand filling and embankment; (3) sometimes a fascine mattress, consisting of several layers of woven branches, is laid first to aid in the even compression of the soft layers; (4) in a few sections where the marshy subsoil is very deep, the roadbed is laid on a concrete trough supported on long wooden piles. These methods are often used for the foundations of secondary roads, as well as of principal highways. Secondary roads are also often built over old road foundations, or over old brick-paved roads. Local roads, from farm to village or across polders, are frequently unsurfaced and become muddy in wet weather.

b. Effects of Inundation on the Roads. The wet subsoil of the area, and the danger of floods in certain regions -- along the Ijssel River, for instance -- have caused Dutch road builders to adopt types of road construction most resistant to the effects of water. Sand embankments are considered a superior type of foundation in areas subject to flooding. The presence of water in the embankment does not cause a change in the volume of the sand mass, as it would in a less stable mixture with a high percentage of clay and other colloidal materials, and therefore subsidences of the sand embankment are not ordinarily to be expected.

Communication by way of the Rijkswegen (superhighways) and other principal highways would not be interfered with by flooding, since these roads are generally built on embankments 5 to 10 feet above the surrounding ground level. Furthermore, since these embankments are of sand or of highly stabilized sand mixtures, the probability of serious permanent damage as the result of inundation is not very great. Some slumping might possibly take place in the flooded section of the Hague-Utrecht superhighway near Harmelen. When this road was constructed in 1938 through an area of soft subsoil between the Ijssel and Oude Rijn rivers formerly avoided by road builders, settling of the foundation was expected to continue for some time, and only temporary surfaces were laid on the carriageways, to be replaced at some later time by a permanent surface of concrete. Flooding might also offer some danger of subsidence in the embankment on sections of this same road west of Gouda, where the soft subsoil is 20 to 30 feet deep.

Since secondary roads are usually built not much above the level of the surrounding ground, road communications into some areas off main highways may be temporarily cut. This is true in particular of the area between Edam and Hoorn (north of Amsterdam), the regions of Ijsselmonde and Beierland (south of Rotterdam), the approaches to Hellevoetsluis on the island of Voorne-Putten, and the larger part of the island of Schouwen-en-Duiveland. Most roads of this classification, however, have substantial foundations of sand, or are built over older roads well impacted by long use, and will probably stand up well under inundation.

Minor roads, especially on the islands of the provinces of Zeeland and Zuid-Holland, may be expected, however, to have suffered serious damage. In the polder

areas, in particular, it will probably be necessary to level such minor roads completely and to rebuilt them from the foundation up.

The principal purpose of the inundation, as far as roads are concerned, seems to be the strategic one of preventing deployment from main highways and of leaving only a minimum number of points at which the defense line must be completed by mining, road-blocks, or demolition of bridges.

4. Railroads

a. Construction and Other Characteristics of the System. The railroad system of the Netherlands is a medium-sized network of about 2,280 miles. It is operated according to modern methods. It has large ratios of double track and electrified lines (46 and 14 percent, respectively). The Dutch system is essentially a passenger system, the inland waterways being all-important in freight transportation. Practically no freight in bulk is carried by rail; coal is transported mostly by water, and agricultural produce by road and water. There is no ore and little oil transported by rail.

Insufficient information is available to give a clear picture of the methods and materials used in railroad construction. However, in view of high Dutch standards of efficiency in other phases of railroading and of what is known of the construction of roads, it can be assumed that the principal railroad beds, which sustain greater and more heavily concentrated loads, were built and reinforced to withstand great external pressure, and to resist the effects of water. The embankments on which the track is laid are sand, and extend down several feet in the soft ground. They are often of considerable height, and of such bulk that heavy moving loads have little effect on them. Retaining

walls of concrete are used where the ground is incapable of carrying a heavy load. Deformation of the roadbed appeared during construction of the main lines, but these defects were remedied and the roadbed was not further affected, even with the introduction of increased traffic and heavier vehicles.

b. Lines in the Flooded Areas. The pattern of flooding is such that some sections of all the principal lines running south, east, or north from the great ports in the west are in flooded land. The length of each section in the flooded areas is small in most cases (see Table 6). The approximate total length of these sections is 84 miles. These lines are generally on high embankments or dikes; usually more than 8 feet high, except in the Hardinxveld area where the line is on an embankment of about 3 feet and in the Kampen and Mastenbrock areas where no embankments appear. These sections of the line may be unusable.

It is believed that the main railroads have not been seriously damaged by flooding. However, the capacity of the main lines may have decreased wherever the speed has to be reduced on sections in the flooded areas. In the case of secondary lines, which by definition are more lightly constructed, some slumping or movement of the substructure may have resulted from the flooding.

Since the economy of the Netherlands does not depend on rail transport to any great extent, essential traffic will not be seriously interrupted so long as other means of transport are available. Railroads are not important for local distribution of supplies, since they generally run in straight lines from one city to another. Probably the deciding factors in the amount of traffic that can be carried by rail when the rest of the Netherlands is liberated, will be the supply of equipment and the condition of facilities,

bridges, and other structures. It has been reported that in recent months the Germans have withdrawn a great number of locomotives from the Netherlands.

B. Communications

1. Nature of the System. The extension of networks and type of equipment in the communication facilities of the Netherlands are exceptionally well-developed. The telephone system, the most important means of communication, is automatized throughout the country, and the chief cities have been connected to a national dialing network. (The original plan, calling for 100 percent automatization by 1945, was interrupted by the German invasion.) Almost all telephone and telegraph lines are laid in underground cable. Only a few isolated telephone subscribers have overhead lines, and even these must be underground at cable junction points. Cables are routed along main highway dikes, and usually are buried at a depth of 30 to 36 inches at either side of the road. The cables are armored[1] and laid directly in the ground. Where there is cross traffic, the cable is covered with concrete slabs for additional protection. The general telegraph network duplicates the telephone network; the lines are laid in the same cables. Radio diffusion networks are also used for communication although only one-way service is provided.

2. Effects of Flooding. Inundation probably has not caused serious interruption of communications in the Netherlands. In the first place, the extensive communications network means that tandem routing or alternate service can be put into use during an emergency period. In the second place, flooding as of 11 October 1944 is confined largely to rural areas, and thus any damage done by flooding would

1. The older cables have wire armoring, but it is believed that all cables laid in the last 15 years are tape-armored.

affect mainly line connections and small centrals rather than the heavier installations in large cities. Line equipment is much easier to repair or replace than central equipment. Since the cable sheath is water-proof, the lines, unless damaged or cut in some way (e.g. by bombing or demolition), are not particularly vulnerable.

The friable nature of the soil does suggest the possibility of undermining and slumping of highway dikes along which cables are routed, with consequent injury to the cables. But because of the relative shallowness of the floodwater and because of their special sand construction, none of the main highway dikes is expected to be seriously damaged. Even in the smaller dikes cables will not be broken easily, although continued pressure may crack the lead sheath or cause short-circuiting. More important, slumping may expose the cables and thus increase the chance of mechanical injury to the sheat.[1] Once a flaw appears in the sheath, the type of insulation (air, paper, and string) increases the susceptibility to water. Even a small crack may allow the dampness from a high water-table or actual floodwater to seep into the cable for a distance of 200 yards, with consequent short-circuiting or destruction.

3. Areas Affected. Communications will have been most hard hit throughout the province of Zeeland. The islands of Schouwen and Tholen are probably completely inundated; in them floodwater will have affected the smaller central and station equipment as well as endangered cable lines. The partial inundation of Walcheren, however, is more important because of the possible damage to heavy central

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1. The extent of demolition and bomb damage is unknown, but the strategic importance of highway dikes will make them vulnerable to attack, and many of the cables in them will have been cut or at least damaged.

equipment in Middelburg[1] and in Flushing. Haarlem is the only other important city in the Netherlands in which a part of the central equipment may have been flooded. Damage to the Middelburg central would be particularly dangerous because Middelburg is the junction for the cable route to Domburg -- one of the two submarine cable landings in the Netherlands. This same cable, which is the main east-west connection in the southwest section of the country, may have been exposed to flood water again at the neck of Zuid Beveland, just east of Goes. Other flooded areas in which interruption of service may be expected because of flooding of small centrals and of damaged lines, are the islands of Zuid-Holland and areas northwest and southwest of Rotterdam. An inundated strip west of Utrecht crosses the main cables from Utrecht to Rotterdam and Amsterdam. On the Utrecht-Rotterdam route a section of cable running along the low highway dike between Gouda and Harmelen is particularly vulnerable. In the north, cables in the area between Amsterdam and Alkmaar may be exposed to flood water. (See Map No. 5889.)

4. Alternates and Repairs. In most flooded areas, only line repairs will be necessary, and these are relatively easy to make. Damage will probably be remedied first by setting up temporary connections, either along the ground or overhead. However, overhead lines, in many cases, will not be a possible solution because of the basic wood shortage in the Netherlands. The length of time the cable is exposed to water will determine whether a section can be repaired or whether it will have to be replaced.

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1. According to German reports later than 11 October 1944, not only has the whole island of Walcheren been inundated, but the water has reached a depth of 7 or 8 feet. Middelburg is specifically mentioned as having been affected.

On those telephone centrals which are flooded probably none will be permanently injured and only minor parts or wiring will need to be replaced once the water is drained off. Telegraph central equipment is lighter than that of telephone and will be even more easily restored.

While repairs of either kind are being made, although local service might be suspended, the national communications system could continue to operate by tandem routing or by alternate services. The automatic telephone network is ideally suited for this emergency. Its tandem trunking system means that connections short-circuited or otherwise cut off will react as busy and the automatic selector will simply reroute the call via the first available circuit, even if a much longer distance is involved. For example, if the direct cable between Rotterdam and Utrecht is injured, a call will still go through to Utrecht via Dordrecht and s'Hertogenbosch or via The Hague ('s Gravenhage), Haarlem, and Amsterdam.

If line equipment only were damaged, probably none of the large cities in the Netherlands mainland would be completely without telephone service. On the other hand, if central equipment were impaired (e.g. Middelburg) not only would the city itself be without communications, but all the surrounding area would be without service except for strictly local calls. Such a central would also be knocked out as a potential trunk exchange for other inundated areas.[1]

In addition to alternate routing there exists the possibility of the use of alternate services -- telegraph

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1. National dialing involves centralization of networks, so that all long-distance lines of a given area must pass through the nearest large trunk exchange. Fortunately Middelburg is only a local exchange central. There is more potential danger to a city like Haarlem, which is an important group exchange central, or to Rotterdam, which is one of five national exchange centrals for all the Netherlands.

and radio. As indicated above, the general telegraph system will be affected by flood conditions in much the same way as the telephone system. However, the railroad administration has its own special telegraph system, which is largely in overhead wire and should therefore be in good condition.

Another potential means of communication is the radio diffusion system. Rediffusion networks are widely distributed throughout the country, especially in localities not served by telephone. It is an excellent means of distributing information quickly and widely, and the radio link dispenses with the necessity of long-distance wire connections. It is not expected that any of the important broadcasting stations will be harmed by flooding.

Both the telegraph and rediffusion networks will probably be cannibalized for telephone equipment because in the long run the telephone is the vital communications service in the Netherlands.

C. Electric Power

1. General.

a. Importance. Electricity plays a vital role in the economy of the Netherlands as a source of power, light, and heat. In 1939, only 7 villages, with a total population of 14,000, were not served with electricity. It finds extensive use in shipbuilding and marine engineering, in electrochemical and electrometallurgical industries, and in the operation of cranes at ports. Much of the tramway system, as well as the railroads in the west-central part of the country, is electrified. Electrically-driven drainage pumps, on which a great deal of the country depends for its very life, are in the majority; and most of the water supply systems rely on electric power for their operation, with Diesel engines serving as emergency reserves.

b. Power Plants and Transmission Lines. Electricity is generated in the main by medium-sized and large power plants, interconnected only fairly well. The system has a large amount of reserve capacity. The majority of plants are publicly owned, either by municipalities or by provinces, and energy (almost exclusively steam-generated) is supplied ordinarily only within the area of the municipality or province.

The Netherlands does not possess a well-integrated high tension grid, although certain advances have been made during the war years, and plans are in existence for a more complete interconnection of generating stations. Most of the high tension system is underground. The distribution system is quite extensive, and consists mostly of underground cables. Cables are laid in trenches 21 to 39 inches deep, which are later filled and tamped. At road or other crossings, concrete sheets or brick coverings are used to afford extra protection to the cables.

2. Effects of Flooding.

a. On Power Centrals. As of 11 October 1944, the only power plant located definitely within the flooded area is the 118,200 kw Velsen station, owned by the province of Noord-Holland. Situated on the north bank of the Noordzee Kanaal, this plant furnishes electricity to the entire province, with the exception of the cities of Amsterdam and Haarlem. One of its most important customers is the Royal Dutch Steel Works at Velsen, from whose blast furnaces the power plant in turn buys waste gas for

fuel. Velsen is linked by a 50 kv underground cable to the Amsterdam and Haarlem generating stations.

Possibly now on inundated land, or soon to be in the future, are the 34,000 kw steam plant at Haarlem, and the 12,000 kw steam station at Flushing. The Haarlem station feeds the Haarlem district and the electrified railways in the area; Flushing furnishes power to the islands of Walcheren and Noord and Zuid Beveland, in the province of Zeeland. The 3,200 kw Middelburg station, of local importance only, has been placed within an inundated area since 11 October 1944.

The actual damage by flooding to such power plants is difficult to assess. Dutch intelligence sources state that the Germans have allowed the Dutch to dike off important industrial installations before flooding. Although types of such installations are not specifically enumerated, power plants are almost surely among them. If this assumption is incorrect, however, it is still probable that the expected water level of two or three feet would fail to reach any of the vital parts of the stations. On the other hand, if the water rose high enough to partly cover the generating, transforming, and switching apparatus, or the boilers, such a plant could not operate until the water had been drained off, and the affected parts (such as rotors and stators) reconditioned by "baking", flushing, and cleaning. Reconditioning is a relatively simple process.

b. On the Transmission and Distribution Syster. Drainage by flooding to the transmission and distribution system is equally difficult to assess, (1) because available information fails to indicate whether some particular circuits are overhead or underground; and (2) since precise routes of cables and overhead lines, and technical details of construction, are in most cases not known. Those connections known to be in inundated territory are as follows:

(1) Uitgeest-Wormerveer, 50 kv (underground cable)

(2) Utrecht-Nieuwersluis, 10 kv (underground cable)

(3) Utrecht-Woerden, 10 kv (underground cable)

(4) Rotterdam into Putton Island, 10 kv (probably underground cable)

(5) Dordrecht into Beijerland Islard, 10 kv (probably underground cable)

(6) Roosendaal into St. Philipsland and on to Schouwen, 10 kv (probably underground cable)

(7) Roosendaal into Tholen, 10 kv (probably underground cable)

(8) Amsterdam-Naarden, 50 kv (unknown)

(9) Delft-Maasluis, probably 10 kv (unknown)

Almost certainly within inundated territory are the following connections:

(10) The Hague-Rotterdam, 150 kv (underground cable)

(11) Rotterdam-Dordrecht, 150 kv (underground and overhead)

(12) Zuid Beveland-Walcheren Island, with a feeder into Noord Beveland, 10 kv (probably underground cable)

(13) Zeeusch-Vlaanderen (that part of Flanders within southern Zeeland), 10 kv (probably underground cable)

If pumping apparatus were inundated, oil-filled cables would be rendered temporarily unusable. But the only cable known to be of this type is the 150,000-volt, lead-sheathed cable (10 above) running along the south side of the main road from The Hague to Rotterdam. Cables insulated in some other manner would be affected by flooding only if the water rose to a height of six or eight feet, so that its consequent weight sheared them. Operational factors, however, may inflict damage to cables, especially to sheaths, so that flood waters permeate the cable and cause short-circuiting.

3. Significance of Effects of Flooding. The effect of damage by flooding to both plant and line equipment is thus expected to be of a purely temporary character only. Consumers may be cut off for a while from electricity supply, but no permanent damage is expected to result from

inundation. Any situation which arises is expected to result from a combination of flooding, demolition, and operational damage. To meet such a situation the Dutch have ordered 60,000 kw of portable generating equipment, suitable for mounting on barges, in units of 5,000 kw and 10,000 kw. This they estimate will be sufficient to care for emergency needs which can not be supplied from regular generating and transforming equipment still left intact.

D. Gas Supply

It is not expected that serious damage to gas installations will have been caused by inundation. Such plants as may be inundated will be unusable during the period in which they are actually under water, but it should be possible to restore service quickly. No acute shortage of personnel is to be anticipated since the Germans have classified the staffs of gasworks among persons not to be evacuated under any circumstances. It is certainly possible that a shortage of coal or transportation may force many gasworks to cease operations for a time. It is also quite possible for the Germans to do a thorough job of demolition. Hence, the statement that damage will not be serious applies to damage to the plants through inundation only.

The number of gasworks known to be flooded as of 11 October 1944 is relatively small. Of the 11 local gasworks[1] producing more than 10 million cubic meters annually, six -- Amsterdam, Rotterdam, The Hague, Haarlem, Utrecht, and Leiden -- are located in floodable areas but available evidence indicates that by 11 October 1944 none of these had been flooded.

1. Amsterdam, Rotterdam, The Hague, Haarlem, Utrecht, Leiden, Groningen, Tilburg, Nijmegen, Arnhem, Hilversum.

The largest gas-supply network in the Netherlands, located in the southeastern section of the country and obtaining its gas from the coke plants at the Maurits and Emma State Coal Mines in the Province of Limburg, lies well to the east of the flooded areas. The network which is supplied by the coke plant at Ijmuiden is partly located in flooded areas. However, inasmuch as severe damage was inflicted on the Ijmuiden plant during an air attack in 1943, any interruption in service is more likely to be attributable to the damage caused by this bombing than to inundation of the area supplied by the network.

E. Water Supply Systems

As far as is known no important water supply installations in the Netherlands were in areas flooded as of 11 October 1944. However, even if installations such as pumping stations and treatment plants were flooded, damage would probably not be serious nor would extensive repairs be necessary once the water were drained off.

It is the distribution network which seems most likely to be affected by the flooding. If underground distributing pipes in flooded areas are cracked or broken, it may be difficult to effect emergency repairs. Although the larger communities have their own waterworks, the rural communities are commonly served by one or two regional waterworks. In many cases the supply and treatment works may be miles away from the districts to be served by the system and connected to them by a long pipeline. If the areas through which the pipes pass are flooded it may be difficult to mend breaks with the result that whole areas are without water even though they themselves are not inundated.

Surface water pollution, with its serious problems as far as health is concerned, may become widespread as additional areas are flooded. In the western provinces, where

most of the flooding had occurred as of 11 October 1944, the main source of water is ground water from the dune belt. Here it is not expected that water will be polluted at the source although pollution enroute to the consumer may occur.

F. Sewage Disposal Systems

Disposal of sewage in the Netherlands has always presented certain difficulties. Until recently the sewer systems of practically all cities opened directly into rivers and lakes. Most of the rivers are too narrow for self-purification and therefore surface water has been badly polluted by sewage. Conditions have been worse in rural areas where privies are commonly built over ditches and brooks. Inundation will accentuate these difficulties and its effects will be felt especially in the regions along the mouth of the Rhine River south of Rotterdam because of the low land and because of the concentration of population in this area.

There is no evidence that any large sewage treatment plants were located within the areas flooded as of 11 October 1944. In any case, inundation would probably do little permanent damage to sewage installations. Electric sewage-pumping stations might be put out of commission which would cause stasis of sewage in collection canals. While such would probably mean only temporary interruption of sewage flow to treatment plant or outlet, it could have serious consequences from the point of view of hygiene.

Table 6. SECTIONS OF DUTCH RAILROADS IN FLOODED AREAS[a]

Section of line in flooded area	Approx. length of flooded section (miles)	Railroad line	Maximum axle load metric tons	Remarks	
				General	In flooded area
A. Principal Lines					
1. Bedum-Middelstum	4.3	Utrecht-Zwolle-Groningen-Delfzyl	16	Single-track, steam section of line in flooded area.	Line on embankment or dike 1-2.5 m. high except for about ½ mile.
2. Kampen and Mastenbroek Areas	3.7	Kampen-Zwolle-Almelo	16	Single-track, steam section of line in flooded area.	No embankments shown.
3. Purmerend-Kwadijk-Oosthuizen	8.1	Enkhuizen-Alkmaar (-Amsterdam)	16	Single-track, steam line. No cuttings, important embankments or bridges.	Line on dike 2.5 meters or higher.
4. Uitgeest Area (-Castricum)	2.5	Den Helder-Zaandam-Amsterdam	16	Double-track, electrified line. High embankments on bridge approaches only.	Line on dike 2.5 meters or higher, small canals alongside.
5. Beverwijk-Uitgeest	4.3	Den Helder-Velsen-Amsterdam	16	Double-track, electrified line. High embankments on bridge approaches only.	Line on dike 2.5 meters or higher, small canals alongside.
6. Sloterdijk-Halfweg	3.7	Ijmuiden-Haarlem-Amsterdam-Amersfoort-Deventer-Oldenzaal-German Frontier (-Bentheim)	16	Double-track, electrified line. High embankments only at bridge approaches.	Line on embankment 1-2.5 m. high. In Halfweg line is on dike 2.5 m. or higher.
7. West of Halfweg-East of Haarlem	2.5	Ijmuiden-Haarlem-Amsterdam-Amersfoort-Deventer-Oldenzaal-German Frontier (-Bentheim)	16	Double-track, electrified line. High embankments only at bridge approaches.	Line on embankment 1-2.5 m. high alongside canal which has road and tramway on opposite side.

a. Sections of lines in flooded areas shown in this table may differ from Map No. 5889 owing to the use of more recent information in this table.

Table 6. (Cont'd)

Section of line in flooded area	Approx. length of flooded section (miles)	Railroad line	Maximum axle load metric tons	Remarks: General	Remarks: In flooded area
8. Amsterdam Area (Watergraafsmeer section and south of Rietlanden)	1.9	Ijmuiden-Haarlem-Amsterdam-Amersfoort-Deventer-Oldenzaal-German Frontier (-Bentheim)	16	Double-track, electrified line. High embankments at bridge approaches. Includes Rietlanden and Watergraafsmeer classification yards and Dyksgracht freight station.	Sections on dike.
9. Amsterdam (Watergraafsmeer)-Duivendrecht-Vreeland	6.8	Amsterdam-Utrecht-'s Hertogenbosch-Tilburg-Belgian Frontier (-Baarle Nassau)	16	Double-track, electrified line. High embankments only at bridge approaches.	Line on dike 2.5 meters or higher.
10. Niewersluis-south of Breukelen	5.0	Amsterdam-Utrecht-'s Hertogenbosch-Tilburg-Belgian Frontier (-Baarle Nassau)	16	Double-track, electrified line. High embankments only at bridge approaches	Line on dike 2.5 m. or higher alongside Norwede Canal as far as Breukelen. Roads along both sides of canal.
11. Breukelen-Harmelen and southwest of Harmelen	5.0	Hoek van Holland-Rotterdam-Amsterdam	16	Double-track, electrified line. High embankments only at bridge approaches.	Line on dike 2.5 m. or higher. Small canals on both sides.
12. Utrecht (south of Lunetten Junction)-Houten	3.1	Amsterdam-Utrecht-'s Hertogenbosch-Tilburg-Belgian Frontier (-Baarle Nassau)	16	Double-track, electrified line. High embankments only at bridge approaches.	No information.
13. Zoetermeer Zegwaard-Zevenhuizen Moerkapelle	2.5	Gouda-The Hague	16	Double-track, electrified line. Very flat country, embankments only at bridge approaches.	Line on dike 2.5 m. or higher.
14. Overschiedam area (south of Delft)	1.9	(Amsterdam-) Haarlem-The Hague-Delft-Rotterdam-Dordrecht-Roosendaal-Belgian Frontier (-Esschen)	16	Double-track, electrified line. High embankments only at bridge approaches and in towns.	Line on dike 2.5 m. or higher; small canals alongside.

Table 6 (Cont'd)

Section of line in flooded area	Approx. length of flooded section (miles)	Railroad line	Maximum axle load metric tons	Remarks: General	Remarks: In flooded area
15. North of Schiebroek-Berkel	3.1	Rotterdam-Berkel-The Hague and Scheveningen	16	Double-track, electrified line. This line is built on very soft soil formation. It has no important embankments or cuttings and only small bridges and culverts across the numerous canals and drains on its course.	Line on dike 2.5 m. or higher; small canals alongside.
16. Niewerkerk area	1.9	Hoek van Holland-Rotterdam-Utrecht-Arnhem-Zevenaar-German Frontier (-Emmerich)	16	Double-track, electrified line. Marshy soil and weak embankment in sections before and after Gouda. Railroad on soft soil formation in flooded area.	Line on dike 2.5 m. or higher.
17. North of Zwijndrecht and Barendrecht areas	3.1	(Amsterdam-) Haarlem-The Hague-Rotterdam-Dordrecht-Roosendaal-Belgian Frontier (-Esschen)	16	Double-track, electrified line. Cuttings and high embankments only at bridge approaches.	Line on embankment 1-2.5 m.
18. Section of Ijsselmonde-Pernis Port Line (Rotterdam)	0.6	Pernis-Ijsselmonde station	16	Several port sidings. Docks on left bank as far down as Pernis (12 miles).	Line on dike 2.5 m. or higher for approx. half of distance in flooded area.
19. Hardinveld area	1.9	Hoek van Holland-Rotterdam-Dordrecht-Nijmegen-German Frontier (-Kleve)	16	Double-track section of steam line. High embankments only at bridge approaches. Several short span bridges, flood openings and drains in flooded area.	Line on earth embankment less than 1 meter.
20. South of Meppel area (Lankhorst)	1.2	Utrecht-Zwolle-Meppel-Groningen-Delfzijl	16	Double-track, steam line.	Line on dike 2.5 m. or higher except in and immediately outside Meppel.

Table 6 (Cont'd)

Section of line in flooded area	Approx. length of flooded section (miles)	Railroad line	Maximum axle load metric tons	Remarks	
				General	In flooded area
21. West of Kesteren-Opheusden	5.6	Hoek van Holland-Rotterdam-Dordrecht-Nijmegen-German Frontier (-Kleve)	16	Wadenoyen-Kesteren is single-track; Kesteren-Nijmegen-(Kleve) is double-track steam line. High embankments only at approaches to large bridges.	No information.
22. Flushing area	2.5	Flushing-Roosendaal-Eindhoven-Venlo-German Frontier (-Kempen)	16	No high embankments or cuttings.	On dike 2.5 m. or higher; alongside Walcheren Kanaal, embanked road and tram on other side.
B. Secondary Lines					
1. Kwadijk area	2.0	(Zaandam-) Kwadijk-Edam-Volendam[a]	13		Line on dike.
2. Aalsmeer-south of Bovenkerk	2,5	Aalsmeer-Bovenkerk[a] (-Amsterdam Willemspark)	16	Light permanent way, no high embankments or cuttings, many small bridges and culverts.	Line on dike 2.5 m. or higher. Line in Oostcinder Poel Polder is diked only on one side (about 2 miles).
3. Hazerswoude Koudekerke area	2.0	Woerden-Leiden	16	Line traverses flat country with numerous canals, small bridges and culverts. No high embankments, cuttings or important bridges	Line on dike 2.5 m. or higher; small canals alongside.
4. Schipluiden area (south of Delft)	2.5	Delft-Loosduinen[a]	16		Line on dike except for short distance at Schipluiden station; alongside canal with diked road on other side except in Schipluiden (1 mile).
Total length of sections in flooded areas	84.2				

a. Light railroad.

IV. THE POPULATION AFFECTED BY FLOODING IN THE NETHERLANDS

A. Introduction

The inundation measures taken in the Netherlands before 11 October 1944 are estimated to have resulted in the flooding of 363,000 acres with a population of approximately 412,000.[1] Most of the flooding has taken place in rural areas. As of 11 October 1944, only three large cities -- namely, Haarlem, Middelburg and Flushing -- had been flooded, but none of these was totally inundated.

The figures discussed in this report are for inhabitants situated in flooded areas and not for persons evacuated because of flooding. The latter probably constitutes only a small fraction of the first since there are many persons who have not left their homes and are still living in areas which have been inundated.

B. Estimates of Population in Flooded Areas

The figures for inhabitants in flooded areas which are given in Table 13 are maximum estimates. They are based on official Dutch statistics for the resident population of November 1943. Important discrepancies will arise from the fact that these statistics do not allow for population displacement caused by emigration of Dutch workers. There is also fairly conclusive evidence

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1. The commune is used as the basic unit for determining the population in flooded areas. All such estimates are necessarily based on the assumption that there is an even distribution of population throughout the commune. The amount of area flooded is indicated per commune on a map of inundation with a scale of approximately 1:500,000.

   Population statistics are based on the following data: (1) the 1930 census which gives figures for all communes as well as for provinces; (2) the November 1943 registration which gives only the figures for communes of over 20,000 population in addition to the province figures. Because there is no 1943 population breakdown for communes of less than 20,000 -- areas in which most of the flooding has occurred -- an average percentage increase had to be determined for total "rural" area in each province with the arbitrary distinction that communes of over 20,000 population are urban and those with less than 20,000 population are rural. This average percentage increase for rural province population was then applied to the individual communes concerned.

that they do not allow for internal migrations resulting from strategic evacuations and from bomb damage. Table 17 is included to show how large these population displacements are estimated to have been in February 1944, the month in which flooding started. Population figures for the westernmost provinces, in which most of the flooding has occurred, will be particularly high since these are the provinces which had the largest decreases in population prior to February 1944. The general movement has been from west to east, and by February 1944, it was estimated that 225,000 inhabitants had been transferred to the eastern provinces.

No attempt has been made to correct the estimates for populations in flooded areas, with reference to such population displacements, because (1) there is no basis for allocating population displacements prior to February 1944 to specific communes -- the basic units used for making flooding estimates, (2) population displacement figures, since they are shown only by provinces, cannot indicate the numbers of persons who may have been forced from their homes but who have not moved out of their own province, and, more important, (3) there is no way of determining how many of the total displaced persons were driven from their homes in anticipation of flooding as opposed to those evacuated because of bomb damage, strategic exigencies, or a combination of all three factors.

The estimated total number of persons in flooded areas is relatively small, representing only 4.5 percent of the total population of the Netherlands.[1] Zeeland is the province whose population has been most affected by flooding. Not only is the inundated area extensive but it includes urban centers, such as Middelburg and Flushing. Approximately one-fourth of the population is estimated to have been living in areas which were flooded as of 11 October 1944. In Zuid-Holland, there may also be a serious problem of displaced persons in regions south of Rotterdam and along the

1. On the other hand, there has been considerable flooding since 11 October 1944 which has not been accounted for in the above estimate; since that date Middelburg was reported completely inundated.

Table 7. DUTCH POPULATION IN FLOODED AREAS.
(Estimated as of 11 October 1944)

Province	Population Nov. 1943	Estimated Population in Flooded Areas 11 Oct. 1944	Estimated % of Netherlands Flooded 11 Oct. 1944	Estimated % of Population in Flooded Areas Nov. 1943
Noord-Holland	1,665,289	120,100	5.8	7.2
Zuid-Holland	2,123,680	195,800	21.0	9.2
Zeeland	257,131	68,700	28.0	26.8
Noord-Brabant	1,108,453	4,700	.74	.42
Utrecht	512,361	18,100	7.6	3.5
Limburg	657,672	None	None	None
Gelderland	999,904	None	None	None
Overijssel	611,603	4,800	1.2	.78
Drenthe	259,616	None	None	None
Friesland	143,031	None	None	None
Groningen	436,725	None	None	None
Total	9,109,695	412,200	4.5	4.5

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banks of the Rhine because of the large concentration of population in this area. The inundated areas in other proyinces are strips of land usually not more than five to seven miles wide and mainly agricultural in character.

C. Possible Solutions to the Displaced Persons Problem

The problem of persons displaced by flooding is difficult to separate from the overall problem of persons uprooted by all the concomitants of war, and its permanent or temporary solution can only be considered realistically in terms of answers to the larger problem. Possible solutions include:

1) The taking over of accommodations left by foreign civilians and by German occupation forces.

2) The temporary housing of many of the affected persons in nearby areas while they are employed in the reclamation of flooded lands.

3) The starting of new communities in land annexed from Germany.

The estimated number of foreign civilians in the Netherlands in February 1944 was 33,200. (See Table 8). This figure includes German officials, German evacuees, and foreign workers of various nationalities, but does not include German occupation troops and expatriates who established residence before the war. Nearly two-thirds of the foreigners are located in the eastern provinces. Assuming that with the end of German occupation these foreigners are moved out of the Netherlands, the accommodations set free could be taken over by evacuees and displaced persons. Also, barracks used by German occupation troops may be utilized for temporary housing.

Many persons in flooded areas have not left their homes, and undoubtedly a considerable number will want to remain and work on reclaiming lands which have been flooded. Reclamation may begin soon after the Allies take over the country and displaced persons sent back to work on draining and cultivating lands within their own provinces.

Table 8. DUTCH POPULATION MOVEMENTS BY PROVINCE[a].

(Estimated as of February, 1944)

Province	Number of Dutch Abroad	Number of Foreigners in the Netherlands	Net Internal Migration[b]	Estimated Population Feb. 1944	Percentage Change in Population
Noord-Holland	212,000	2,500	- 138,000	1,383,500	- 25.1
Zuid-Holland	185,000	3,500	- 135,000	1,905,300	- 16.6
Zeeland	12,500	1,400	- 46,000	197,000	- 29.0
Noord-Brabant	83,000	2,100	+ 50,000	1,027,800	- 3.0
Utrecht	44,000	2,500	+ 30,000	479,500	- 2.4
Limburg	23,000	4,200	None	607,600	- 3.1
Gelderland	24,500	10,000	+ 120,000	1,055,300	+ 10.4
Overijssel	22,500	3,000	+ 34,000	606,500	+ 2.1
Drenthe	12,600	1,400	+ 21,000	264,600	+ 3.7
Friesland	6,950	1,000	+ 29,500	462,300	+ 5.1
Groningen	5,950	1,500	+ 34,500	468,000	+ 6.5
Total	632,000	33,200		8,457,000	

a. Source: Displacement of Population in the Netherlands, Economic Warfare Division, American Embassy, London, March, 1944.

b. These figures include coastal evacuees plus all other displaced persons.

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Another possible solution is the colonization of Dutch farmers on territory annexed either temporarily or permanently from Germany. (See Section V)..

V. GERMAN TERRITORY FROM WHICH AREAS FOR POSSIBLE COMPENSATION MIGHT BE CHOSEN

Since much of the land that has been or may be flooded in the Netherlands is primarily agricultural, the most suitable compensation would be land similar in character and adjacent to the Dutch border. If maximum flooding were carried out, the area of the polders in that part of Germany adjacent to the Netherlands would not be large enough to replace the flooded polders. However, in the German polder belt and in the somewhat higher area to the south there is much unreclaimed land that might be considered as possible compensation. But the cession of such land to the Netherlands would not solve the immediate problem of agricultural produce to replace that lost in the flooded regions.

Physical conditions and cultural characteristics are similar on both sides of the Netherlands-German border. The West and East Frisian Islands consist of sand dunes and small districts of marshland on the leeward side. Between the islands and the mainland is the so-called Watten, an stretch of shallow water, in which mud flats are exposed at low tide, except for channels of rivers that cross the flats. The coast line is in large part protected from unusually high tides by dikes. Behind the dikes, is a broad flat plain, in which are several districts of productive polders. (See Sketch Map of Types of Land). From the polder belt to the Rhine Valley the land consists primarily of higher, sandy and less fertile areas, called geest. Throughout the German region, as in adjacent sections of the Netherlands, agriculture is the chief economic activity. Some districts were at one time in political union with the Netherlands. Today certain cultural traits, such as language, religious affiliations, methods of farming, and even house types, are

7°
8°
9°
54°
53°
MER DU NORD
Cuxhaven
Nordeney
Borkum
Jade Busen
Bremerhaven
Aurich
Dollart
Emden
Ems
Leda
Oldenburg
Brême
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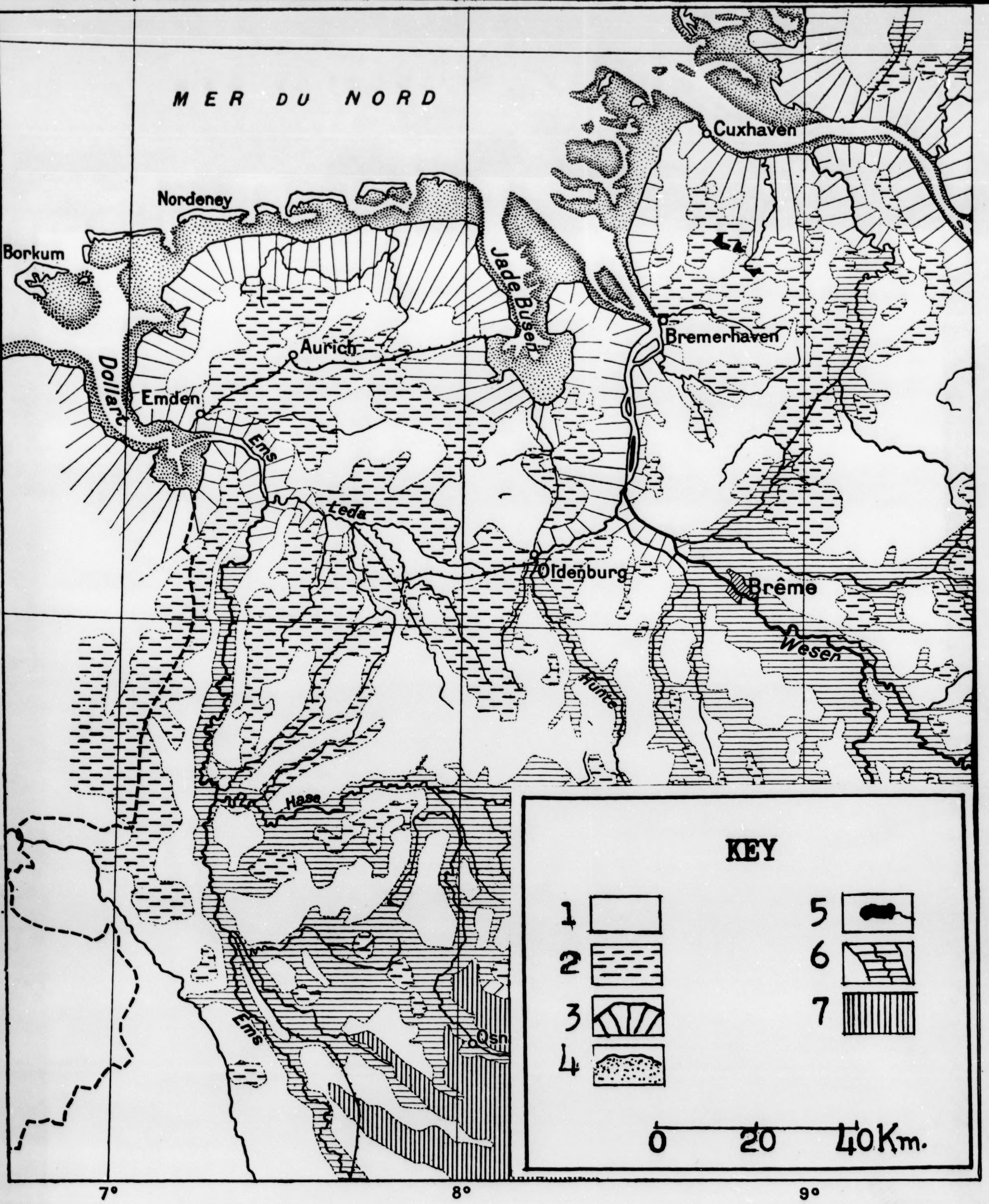


Sketch Map of Types of Land

1. Geest, Soil generally sandy; 2. Moor, Swamp with peat-bog; 3. Marschen, Marsh-lands; 4. Watten, Tidal flats; 5. Lake, generally surrounded by peat-bog; 6. River flood plains; 7. Highlands.

Source: Géographie Universelle

alike on both sides of the international boundary. Since the German lands are similar to those across the border, their use would be facilitated in case they were given to the Dutch as compensation for flooded lands in western Netherlands.

A. Character of the German Area Adjacent to the Netherlands

1. Terrain. There is considerable diversity between the dune, polder, and geest belts in their physical characteristics and in their adaptability for agricultural and other uses.

The West and East Frisian Islands are a northward extension of the dune belt along the coast of western Netherlands. The sand dunes, which rise to a height of fifty feet or more, are in some cases used for the location of lighthouses. The small areas of marshland on the leeward side of the East Frisian Islands in contrast to those of the Dutch West Frisian Islands are little used for agriculture. In several small towns and fishing villages the population caters to tourists during the summer.

The most productive agricultural land in the portion of Germany adjacent to the Netherlands is in the polder belt. Much of the polder belt lies below the level of high tide. Portions of these marshlands (marschen) have been worth the time and cost of diking and draining to form fertile polders. Dairying is the dominant activity in the polder belt, but cereals, sugar beets, flax, and vegetables are cultivated in those polders where the soil is free from salt. Farm products are marketed in these districts as well as in industrial areas to the south. However, in Germany this belt in general has been less intensively utilized than similar land in the Netherlands and consequently has a less dense population.

In contrast to the polder belt the geest is much less

valuable for agricultural purposes and is sparsely inhabited. The geest, a sandy undulating plain, seldom exceeds 150 feet above sea level, but here and there ridges of sand and gravel rise above this height. In general, the geest is composed of two types of soil and vegetation cover, the heath (Sandgeest) and the moor (Moorgeest). These two types differ greatly in appearance, in top soil, and in their value for agricultural use.

The heath lands are those portions of the geest in East Friesland and several parts of Hannover, as well as sections of northeastern Netherlands, where the surface soil is dry owing to the pervious nature of the underlying sands and gravels and the resultant deep-seated water table. On the dry infertile soil, the natural vegetation cover consists of heath with scattered clumps of birch, juniper, poplar, and pine. However, small districts of the heath have been made productive by heavy fertilization.

The moors, in general sterile and thinly people, are characterized by a greater abundance of moisture in the soil because of an impervious layer a few feet below the surface -- a condition that has favored the development of peat bogs. The largest bogs lie in East Friesland and on both sides of the Ems. East of the Ems the Leda River separates the Arenberg Moor from the Lengener Moor whereas west of the Ems a broad moor extends along the Dutch Frontier as far south as the Rhine at its westward swing into the Netherlands. The greater part of this area is known as the Bourtanger Moor, much of which lies within Dutch territory. The moor does not readily support a productive agriculture and its scanty population has to wring a hard livelihood from the infertile soil. The moor has been utilized chiefly as inferior pasture.

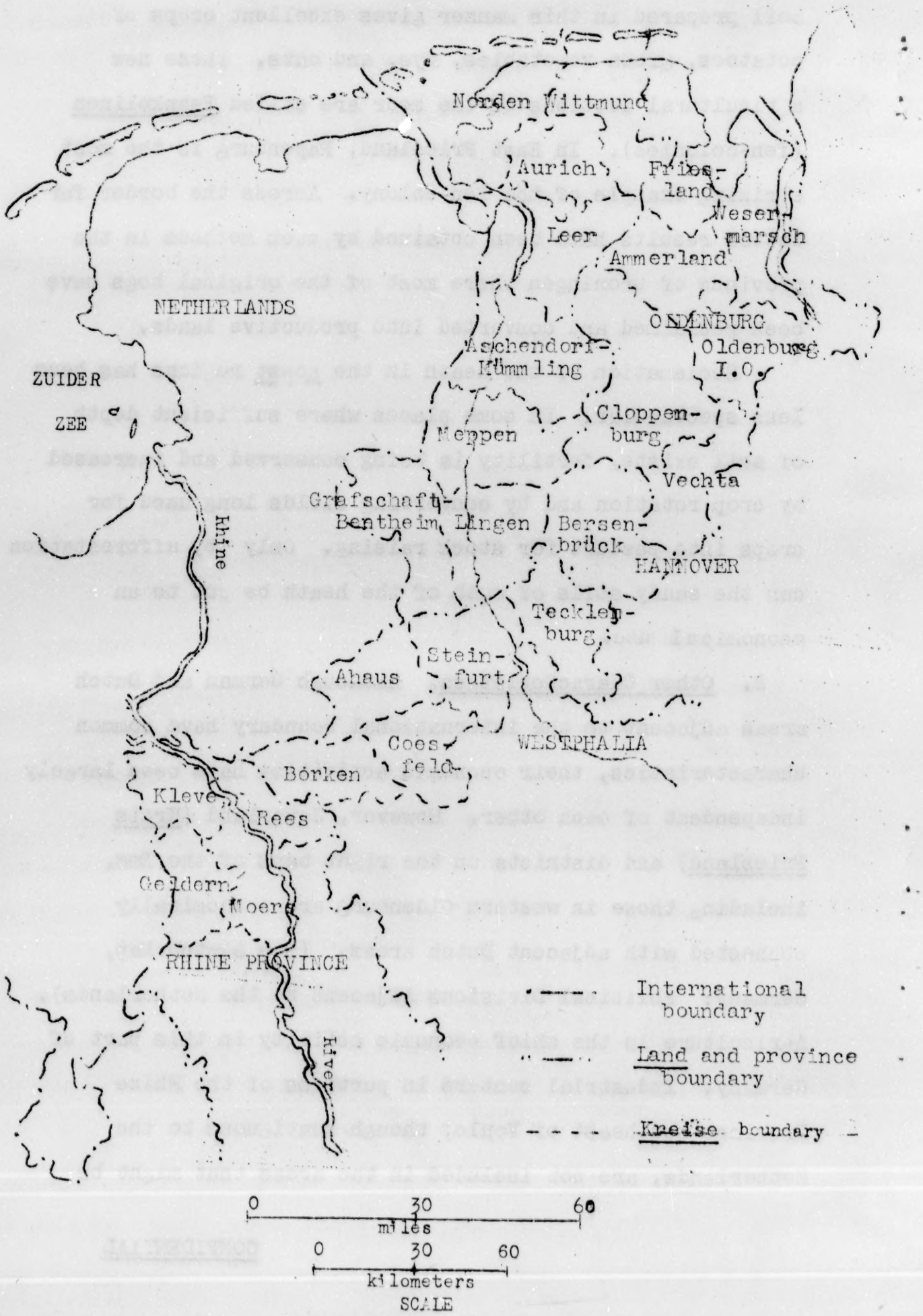
In East Friesland, however, considerable sections of bog and moor land have been reclaimed within the last 60 years by the Dutch system, which involves the removal of the surface peat, mixing the underlying sand with peat, marling, manuring, and adding silt dredged from the rivers. Soil prepared in this manner gives excellent crops of potatoes, green vegetables, rye, and oats. These new agricultural sections on the moor are called Fehnkolinen (fen-colonies). In East Friesland, Papenburg is the most striking example of the fen-colony. Across the border far better results have been obtained by such methods in the province of Groningen where most of the original bogs have been reclaimed and converted into productive lands.

Reclamation of the heath in the geest regions has been less spectacular. In some places where sufficient depth of soil exists, fertility is being conserved and increased by crop rotation and by converting fields long used for crops into pasture for stock raising. Only by afforestation can the sandy soils of much of the heath be put to an economical use.

2. Other Characteristics. Although German and Dutch areas adjacent to the international boundary have common characteristics, their economic activities have been largely independent of each other. However, Jeverland (Kreis Friesland) and districts on the right bank of the Ems, including those in western Oldenburg are economically connected with adjacent Dutch areas. (See Sketch Map, Germany: Political Divisions Adjacent to the Netherlands). Agriculture is the chief economic activity in this part of Germany. Industrial centers in portions of the Rhine Province southeast of Venlo; though contiguous to the Netherlands, are not included in the areas that might be

SKETCH MAP

GERMANY: POLITICAL DIVISIONS ADJACENT TO THE NETHERLANDS



ceeded as compensation. It has been suggested that, since the German area adjacent to the Dutch border in Oldenburg, Hannover, and Westphalia is rural and sparsely populated, it might be used for the relocation of displaced Dutch population. However, much of this land has not been reclaimed and hence is not available for immediate settlement. Reclamation in the polder belt, heath or moor would involve considerable time and capital expediture, so that cession of such land to the Netherlands could not solve the immediate problem of substitute areas for the flooded regions. Nevertheless, such might be feasible if the land were to become permanent Dutch territory. (See tables 9, 10, 11, 12, 12, 14 and 15 at the end of this section).

a. Language and Religion. Both language and religion link the border areas of Germany with those of the Netherlands. On both sides of the border Lower Franconian, Lower Saxon and Frisian dialects are spoken. For many centuries the Dutch language was official throughout these lands, but its use was discontinued in most of them about 1818; it was used in church and school, and even persisted in Kleve as late as 1825. However, dialects are still spoken in the countryside of Bentheim, Moers, and Kleve; it is only in the written language (which is gaining headway) that linguistic differences are apparent on either side of the political boundary. Among the German Frisians especially, a consciousness of the close connections with the Frisians of the Netherlands still remains strong although the dialect itself has been replaced by Lower Saxon. This consciousness further expresses itself in a retention of Frisian folkways and cultural traits, such as customs, songs, and the type of farmhouse.

Religious affinities, both historic and contemporary, also link the people on both sides of the political boundary.

Like the Netherlands, the western part of East Friesland and all the Grafschaft Bentheim are overwhelmingly Calvinistic. The former Rhenish duchies of Kleve and Geldern were originally Calvinistic, and maintained close connections with their co-religionists in the Netherlands. Even the Evangelical Union of 1817 failed to disturb the basically Calvinistic character of the area. Far into the nineteenth century, all these Calvinistic communities were served by ministers who had been educated in the Netherlands, and Dutch was the language of the pulpit. Although it has now been replaced by German, the consciousness of basic religious ties still remains strong. Notwithstanding these language and religious ties, the Dutch consider these people foreigners and are not anxious to absorb them into their country.

b. Communications Across the International Boundary. Several main rail lines cross the Netherlands border into adjacent portions of the Rhineland and Westphalia. Two main lines go through and connect Grafschaft Bentheim with the Netherlands, whereas the northern area is served only by one main line which connects northeastern Netherlands with East Friesland. More striking, however, is the complete lack of east-west railroad lines through the approximately 45 miles of the Bourtanger Moor.

Road connections are similar to those of the railroads and practically parallel them. Again a striking feature is the absence of main road connections through the Bourtanger Moor. However, many surfaced roads serve the borderlands even though only six main roads cross the entire area from the Dollart to the Rhine.

c. Trade Connections With Germany. Any annexation, whether temporary or permanent, would cut through established

connections within Germany. Animal and fodder products are the principal exports from these areas and they go primarily into the Rhineland and the Ruhr region. (See Table 12 for exports from western Hannover). Import from any part of Germany is insignificant. Kreis Grafschaft Bentheim and perhaps also Kreis Leer in East Friesland have had as much traffic with the Netherlands as with adjacent German districts. On the other hand, the Kreise of northwestern Westphalia and that portion of northern Rhineland under consideration are economically more strongly integrated with the Ruhr region.

C. Areas Considered as Suitable for Compensation in Kind

1. East Friesland and Jeverland. East Friesland and Jeverland border the North Sea and lie between the Dutch boundary and the Jade Basin. East Friesland includes the seven large East Frisian Islands. Although only a small part of the area is below mean sea level, much of the region is reclaimed salt marsh protected by dikes from high tides and storm floods. The area includes portions of geest, primarily the moor type, which is potentially reclaimable. Valuable inundated land in Jade Bay and the Dollart was reclaimed early insofar as primitive technical means of former times allowed. Reclamation in Jade Bay in modern times has not been continued because of the development of Wilhelmshaven as a naval base. More land in both the Dollart and Jade Bay could be reclaimed. Though agriculture is the dominant interest in East Friesland and Jeverland, fishing plays an important part in the lives of those living adjacent to the sea. In coastal districts a considerable tourist trade is experienced during the summer months. The only city of importance in East Friesland is Emden (population: 34,700). It was created with the object of capturing some of the traffic of Rotterdam

for Germany but its importance also lies in its strategic position as the northern terminus of the Dortmund-Ems Canal, which gives it connections with the great coal field and industrial area of Westphalia. Wilhelmshaven, (population: 104,000) contiguous to Jeverland on Jade Bay, has few economic ties with the area as its sole function is to serve as a naval base.

2. The Country East of the Ems. This area, which lies south of East Friesland and Jeverland, includes the Kreise Ammerland and Cloppenburg in Oldenburg and the eastern portions of the Kreise of Aschendorf-Hümmling, Meppen, and Lingen in western Hannover. With the exception of small portions of marshland in the north, and alluvial lands of the Ems Valley and scattered patches of moorland much of this region consists of the infertile geest or heath. Although settled early because of relatively dry soil, the heath is still sparsely inhabited. Agricultural techniques are backward and only a meager subsistence is obtained. As a result, many inhabitants migrate regularly to the Netherlands for seasonal work. The soil of this area is essentially of the same quality as that of the Dutch provinces of Groningen and Drenthe. However, the Dutch have utilized such soil much more efficiently.

3. The Country West of the Lower Ems. This sparsely settled area consists of the western portions of the Kreise Leer, Aschendorf-Hümmling, Meppen, and Lingen. It is largely occupied by the Bourtanger Moor, which is uncrossed by any important railroad or road. On the Dutch side the bogs have been drained and the land is used for agricultural purposes in contrast to the uncultivated moor on the German side. Along the Ems and its estuary however, are rich alluvial soils that have been drained and are effectively utilized.

4. Kreis Grafschaft-Bentheim. The northern portion of Kreis Grafschaft Bentheim is covered by the Bourtanger Moor and the southern portion is also primarily bogland. The contrast between the well-drained, well-cultivated countryside of Netherlands and the swamp land just across the German border is striking. However, the area does have well-settled districts and some small cities (e.g. Nordhorn, population: 23,000). A main feature of Kreis Grafschaft Bentheim is its partial encirclement by Dutch territory with which it is connected by good roads and railroads. In this region of Germany it is one of the few districts that is still Calvanistic.

5. Northwestern Westphalia. Northwestern Westphalia is that area adjacent to the German-Dutch frontier, south of Grafschaft Bentheim. It coincides roughly with the administrative units of the Kreise of Bocholt, Borken, Ahaus, Coesfeld and Steinfurt. It includes the catchment basins of the Vechte, Berkel, and Oude Ijssel. Dutch underground sources have suggested this area as appropriate compensation for flooded lands in the Netherlands.

The area, a part of the drier geest, is located in a corner shunned by through traffic, but its local connections with the Ruhr region as well as with the Netherlands are fairly good. However, only the southeastern part of Coesfeld, which includes the city of Dülmen, is closely tied to the Ruhr. Potatoes and dairy products, the principal agricultural produce, find their market chiefly in the Ruhr.

The natural heath vegetation, which has long supported sheep grazing, furnished an early start to a cottage wool textile industry in this area. Later, a textile industry, financed partly by Dutch capital, developed in a chain of medium-sized towns. These are Bocholt (population: 35,053),

Borken (population: 7,785), Ahaus (population: 6,421), Gronau (population: 18,823), Burgsteinfurt (population: 8,794) and Rheine (population: 34,368). Despite this industrial development farming and grazing are the chief economic activities.

6. Northern Rhineland. This area includes only those parts of the Rhine plain outside the highly-industrialized regions of the Rhine Province. Most of it is a flat alluvial plain below the level of the Rhine, but sandy and gravelly soils are found in the terraces bordering the flood plain. Truck farming is especially profitable because of the natural conditions favoring the growth of vegetables and because of its accessibility to neighboring densely populated industrial areas.

The architecture, agriculture, and customs of Northern Rhineland have been strongly influenced by the Dutch. Most of the area once belonged to the duchies of Geldern and Kleve which were at one time or another united politically with the Netherlands. The sprinkling of Dutch-speaking persons and the large number of Calvanists throughout the area date from that time.

Northern Rhineland has several cities which have grown little since their "golden age" from the 15th to the 17th centuries. Wesel has 24,472 inhabitants (1939); Kleve 21,784; Kamp-Linfort 22,888; and Geldern 6,898. The area half surrounded by Dutch territory is comprised of the Kreise of Kleve, Rees, Geldern, small parts of Kempen-Krefeld north of a line from the Dutch border near Venlo and north of Krefeld, and the northwestern half of Moers, including the city of Moers (the other half recently has been drawn into closer connection with the Ruhr region).

D. Special Problems That Would Be Created by Cession of These Areas

Aside from the typical questions raised by cession of any territory, the transfer of western German border areas, either temporarily or permanently, would give rise to special problems. These include the problems of a boundary and of the Ems-Jade and the Dortmund-Ems Canals.

1. The International Boundary. The establishment and maintenance of a satisfactory political boundary is of paramount importance. The terrain of this region is so uniform that there are few natural breaks except those which have been determined by the presence of bog and heath. The boundary line between western Hannover and the Netherlands follows a break in the continuity of settlement where the Bourtanger Moor has long served to separate the peoples on either side. Often distinct border lines develop between industrial and agricultural areas, as indicated in the Rhineland and the Ruhr regions. With the large extent of heath and moor in this section of Germany, it probably would not be difficult to select a boundary which would pass through sparsely populated districts and which would not be crossed by many main roads or railways. The exact delimitation of such a boundary would have to be based on field studies. If the Ems were chosen as the international boundary, the line would separate important agricultural districts on either side, cut across the Dortmund-Ems waterway in places, and leave just to the east the important road and railway connections between Emden and the Ruhr.

2. The Ems-Jade and the Dortmund-Ems Canal. The Ems-Jade Canal, connecting Emden and Wilhelmshaven, handles local traffic almost entirely in shallow draft barges, whereas the Dortmund-Ems Canal, although a barge canal, handles traffic

to and from foreign countries.

The construction of the Dortmund-Ems Canal was undertaken to provide for the Ruhr region a waterway complete on German soil, and a shorter route to Scandinavia than that via the lower Rhine River. After the completion of the canal, Emden at the mouth of the Ems and the canal grew from an unimportant port, trading in fish and agricultural products, until it occupied fifth place among German ports. (See Tables 13 and 15 at the end of this section). Emden's dependence on the canal is shown by the fact that in 1934, 80 percent of its sea-borne imports consisted of Swedish ore destined for the Ruhr, and 90 percent of its exports consisted of coal and coke intended almost exclusively for the Scandinavian countries (Table 14). The preponderance of barge traffic is shown by Table 15.

The cession of East Friesland or the indicated parts of Hannover would necessitate some international regulation of these canals and the harbor at Emden.

Table 9. OCCUPATIONAL STATISTICS, 17 MAY 1939

Administrative Unit (a)	Resident Population (b)	Agriculture, Forestry, & Fishing	Industry & Handicrafts	Trade & Transport	Government Service & Private Services	Domestic Services	Gainfully active without fixed occup.
Prov. Hannover (part)							
Reg. Bez. Osnabrück (part)							
Kr. Aschendorf- Hümmling	61,719	27,200	12,600	5,400	4,700	700	11,100
City Papenburg	11,637	2,200	5,000	1,800	1,300	300	1,000
Kr. Grafschaft Bentheim	66,072	23,000	28,200	6,000	4,600	1,000	3,300
City Norden	23,290	1,600	16,800	1,800	1,500	400	1,200
Kr. Lingen	47,118	22,200	7,800	9,100	4,100	800	3,100
City Lingen	12,854	200	2,700	5,500	2,600	400	1,500
Kr. Meppen	46,864	22,000	11,700	5,700	3,000	700	3,800
Reg. Bez. Aurich (East Friesland)	291,298	96,200	79,500	53,000	29,400	6,500	26,700
Kr. Emden (Stadtkreis)	34,746	1,700	9,800	14,000	4,400	1,200	3,600
Kr. Aurich	52,312	22,600	14,000	6,300	4,700	800	3,900
Kr. Leer	99,258	34,000	27,300	17,700	9,100	2,000	9,200
City Leer	13,908	800	4,300	3,900	2,500	500	1,900
Kr. Norden	62,226	17,400	18,800	10,900	6,700	1,800	6,600
City Norden	12,306	700	4,100	3,200	1,900	500	1,900
Kr. Wittmund	42,756	20,500	9,600	4,100	4,500	700	3,400
Prov. Westphalia (part)							
Reg. Bez. Münster (part)							
Kr. Bocholt (part)(Stadkreis)	35,053	700	22,200	4,600	2,300	1,000	3,800
Kr. Ahaus	78,677	23,800	35,600	7,800	5,100	1,200	5,200
City Gronau in W.	18,823	800	12,100	2,500	1,600	300	1,500
Kr. Borken	59,233	24,800	19,700	5,900	3,900	900	4,000
Kr. Coesfeld	58,980	19,300	21,200	7,700	4,600	1,200	5,000
City Coesfeld	13,531	400	6,000	3,200	1,800	500	1,600
City Dülmen (c)	10,404	400	5,900	1,600	1,000	300	1,200
Kr. Steinfurt	118,506	22,600	61,000	16,400	7,700	2,200	8,600
City Borghorst	10,869	1,200	7,000	1,100	500	200	800
City Emsdetten	17,235	1,900	11,300	1,700	800	300	1,200
City Rheine	34,368	600	19,200	8,000	3,100	800	2,700

Table 19 (Continued)

Administrative Unit (a)	Resident Population (b)	Agriculture, Forestry, & Fishing	Industry & Handicrafts	Trade & Transport	Government Service & Private Services	Domestic Services	Gainfully active without fixed occup.
Rhine Province (part)							
Reg. Bez. Düsseldorf							
Kr. Geldern	60,371	19,700	20,900	7,400	4,700	1,500	6,200
Kr. Kempen-Krefeld (part)	144,901	19,200	75,900	17,500	10,600	2,600	19,100
Kr. Kleve	87,462	17,000	37,600	10,900	8,400	2,100	11,500
City Goch	13,481	700	8,100	1,900	1,100	400	1,300
City Kleve	21,784	300	10,900	3,800	3,200	700	2,900
Kr. Moers	191,291	19,600	114,400	19,800	10,600	4,300	22,600
City Homberg (c)	26,738	200	16,700	3,600	1,500	600	4,100
City Kamp-Lintfort	22,639	1,700	15,700	1,200	900	400	2,700
City Moers (c)	29,646	1,000	16,700	4,200	2,900	800	4,000
City Neukirchen	10,392	1,800	5,500	800	600	300	1,400
City Repelen-Baerl (c)	15,392	1,600	9,500	1,100	600	400	2,200
City Rheinhausen (c)	40,864	600	30,200	4,100	1,700	800	3,500
Kr. Rees	83,782	17,100	32,300	14,200	8,300	2,400	9,500
City Emmerich	16,381	300	7,900	3,500	2,100	500	2,100
City Wesel	24,472	900	10,300	5,300	3,700	800	3,500
Land Oldenburg	555,916	154,900	140,900	80,700	121,400	10,900	47,100
Kr. Wilhelmshaven (Stadtkreis)	103,842	800	15,700	11,800	63,500	2,100	9,900
Kr. Friesland	59,380	14,900	14,900	7,400	14,900	1,400	5,900
Friesische Wehde	11,912	3,800	3,900	1,200	1,800	200	1,000
City Oestringen	10,974	1,700	1,900	1,000	5,200	200	1,000
Kr. Ammerland	47,805	23,400	11,200	5,000	4,200	700	3,300

(a) All Kreise are Landkreise unless otherwise designated.
(b) Total population minus conscripts in the armed forces and the RAD.
(c) This city is not within the area covered by this study.

Table 10. AGRICULTURAL STATISTICS

	Total Arable Land	Meadows	Cultivated area, 1930 (in thousand hectares)				Average Yield per hectare 1924-29 (in liters)	
			Rye[a]	Wheat[b]	Fodder	Potatoes[c]	Rye	Wheat
Reg. Bez. Aurich (East Friesland)	103	92	23	4	31	8	17.5	23.5
Reg. Bez. Osnabrück	150	87	70	3	28	24	14.7	20.5[d]
Land Oldenburg	137	133	62	1	34	14	16.0	20.5[d]
Reg. Bez. Düsseldorf	252	66	59	29	58	31	19.9	20.5
Reg. Bez. Münster	284	121	95	20	56	31	16.2	16.5

a. Includes summer rye which in no case exceeds 2 percent of the total area devoted to rye growing.
b. Includes summer wheat which in no case exceeds 25 percent of the total area devoted to wheat growing.
c. Includes early potatoes which in no case exceeds 10 percent of the total area devoted to potato growing.
d. This average yield per hectare for the whole Regierungs Bezirk Osnabrück is much higher than the average yield per hectare in the Kreise, Mappen, Lingen, Aschendorf- Hümmling and Grafschaft Bentheim which all have an average yield of about 11-15 liters of wheat per hectare.

Table 11. LIVESTOCK STATISTICS, 1936

(numbers in thousands)

Administrative Unit	Cattle		Sheep	Swine
	Total	Of these Milch Cows		
Prov. Hannover				
Reg. Bez. Aurich	232	109	26	113
Reg. Bez. Osnabrück				
Kr. Aschendorf- Hümmling	49	23	10	6
Kr. Meppen	36	18	10	6
Kr. Grf. Bentheim	47	23	5	9
Kr. Lingen	39	20	3	8
Land Oldenburg				
Friesland	60	25	3	27
Ammerland	57	21	2	57
Prov. Westphalia				
Reg. Bez. Münster				
Kr. Steinfurt	44	20	2	56
Kr. Coesfeld	38	18	1	37
Kr. Ahaus	44	21	1	36
Kr. Borken	44	25	2	38
Rhine Province				
Kr. Rees	42	22	2	35
Kr. Kempen-Krefeld	31	19	4	44
Kr. Mörs	41	22	3	62
Kr. Geldern	36	19	1	52
Kr. Kleve	44	21	2	50

Table 12. EXPORTS FROM WESTERN HANNOVER, 1933.[a]

	Number exported to the Rhine Province and Ruhr region	Number Exported to Southern Germany	Number Exported to Central Germany	Number Exported to Other Parts of Germany
Shoats	185,000	41,000	45,000	65,000
Hogs	107,000	12,000	2,000	36,000
Cattle	40,000	4,000	9,000	4,500
Fodder (tons)	45,000	100	300	1,000

a. From Reg. Bez. Aurich (East Friesland) and the Kreise Aschendorf-Hümmling, Meppen, Grafschaft-Bentheim, and Lingen.

Table ARRIVAL AND DEPARTURE OF SHIPS IN EMDEN HARBOR, 1937.

	Loaded	Empty or in Ballast
Ships entered	1,922	1,822
Ships cleared	3,383	389

Table 14. CANAL AND RIVER-BORNE GOODS TRAFFIC, HARBOR OF EMDEN, 1937
(in thousands of tons)

	Total	Grain	Ores	Coal	Fertilizers	Iron & Ironware	Other Goods
Arrival	2,855	15	4	2,531	-	-	305
Departure	2,767	49	2,552	26	1	34	105

Table 15. VOLUME OF TRAFFIC IN EMDEN, 1933
(in thousands of tons)

	Arrivals	Departures	Total Traffic
Sea borne	800[a]	2,600	3,400
Canal borne	2,800	900[a]	3,700
Rail borne	-	-	1,100

a. These low figures are probably caused by the low productivity of the Ruhr foundries before rearmament under the Nazi regime.